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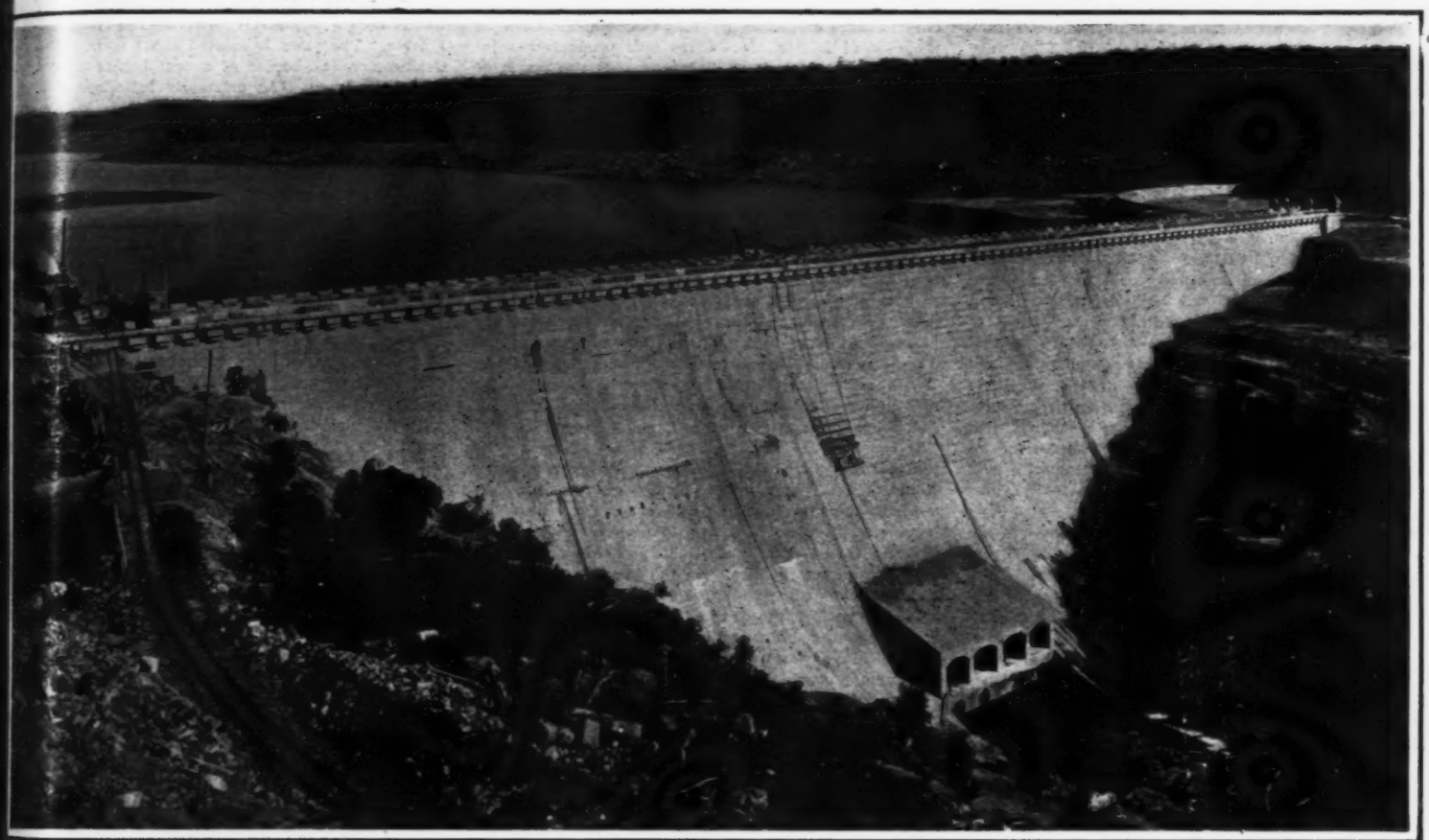
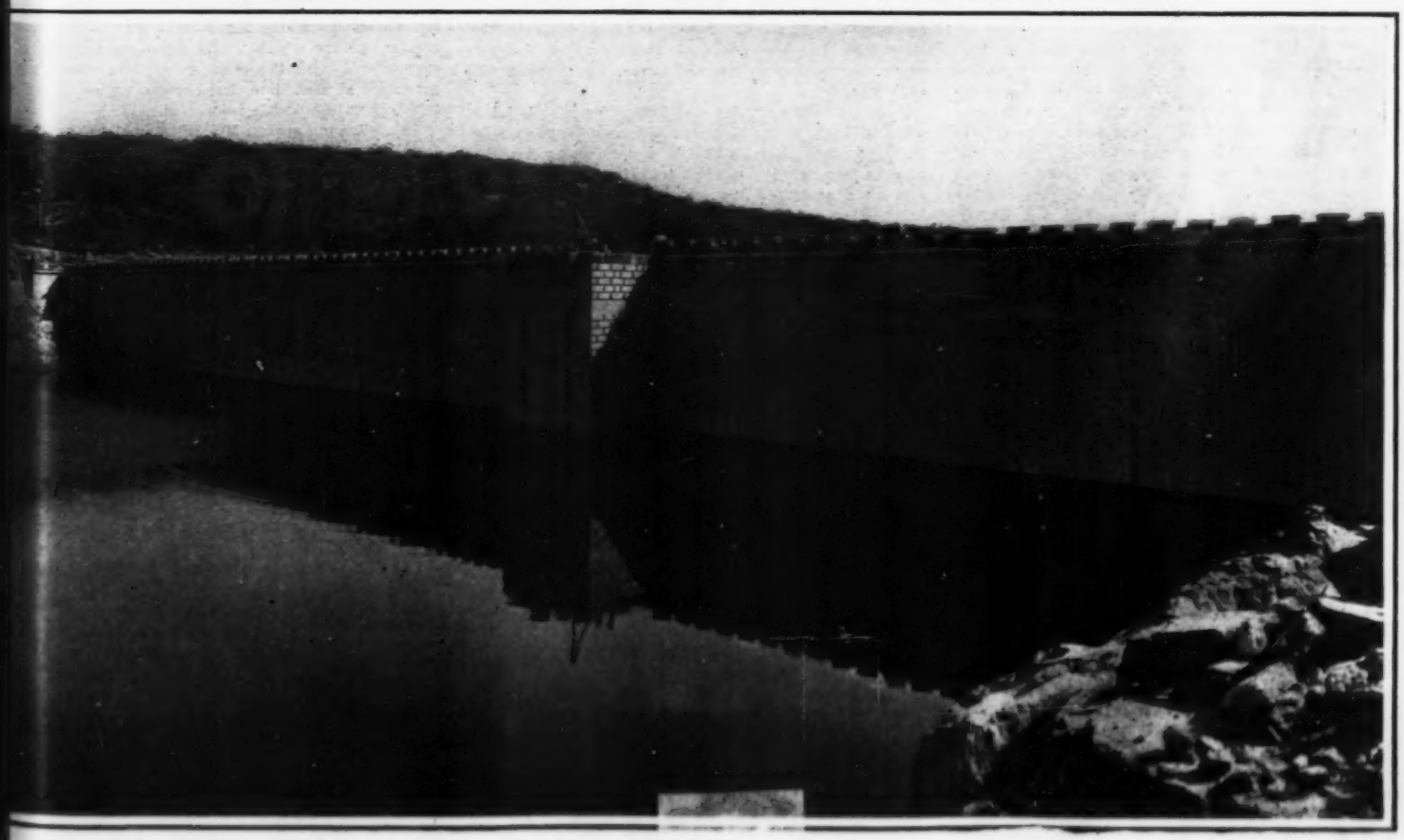


DOWNSTREAM FACE OF CATARACT DAM, SHOWING GATE HOUSE. WATER IMPOUNDED, 21,411,500,000 GALLONS.



UPSTREAM FACE OF NEW CATARACT DAM.

THE NEW DAM FOR INCREASING THE WATER SUPPLY OF SYDNEY, NEW SOUTH WALES.—[SEE PAGE 215]

OUR COAL BRIQUETTING INDUSTRY.—III.*

A COMPLETE REVIEW OF AMERICAN DEVELOPMENT IN A NEW ENTERPRISE.

BY EDWARD W. PARKER.

Concluded from Supplement No. 1682, page 200.

ARIZONA.

THE Arizona Copper Company, Limited, of Clifton, Arizona, installed during 1905 a briquetting plant purchased from Yeadon, Son & Co., of Leeds, England. The plant was put into operation in September, 1905, and produced during the first six months of 1906, 690 short tons of briquettes having a total value of $4,830, or an average of $7 per ton. About 300 tons were produced in experimental runs in 1905. The plant was installed for the threefold purpose of utilizing coke breeze, which is without value and non-usable as such, of procuring better efficiency from the slack coal (Gallup, New Mexico) which is used as fuel, and of obtaining a fuel that could be stored without material deterioration and without danger of spontaneous ignition. James Colquhoun, president of the company, states that the economic advantages realized are from the first and third operations. By briquetting the coke fines or breeze a profit of about $4 per ton is made in the conversion of a material formerly wasted into a usable fuel. In using the Gallup slack, which is sub-bituminous coal ("black lignite"), the expense of briquetting brings the total cost up to approximately $6.80 per ton, or about the same as that of the lump coal obtained from the same source, although the price for the slack at the mines is very low compared with that of lump coal. The briquettes have been found to burn freely and satisfactorily under locomotive and stationary boilers, and appear to be equal to the best of Gallup lump coal, but no laboratory tests as to their calorific power have been made. The real profit in the briquetting of this coal lies in the superiority of the briquettes over lump coal for stacking purposes. They stand weathering perfectly, while the lump coal disintegrates on exposure, loses a portion of its combustible gases, and becomes in time a very inferior fuel. It is also liable to spontaneous combustion, which the briquettes are not.

In making the briquettes 92 per cent of the coal is mixed with 8 per cent of California asphaltic pitch. The capacity of the plant is 2½ tons of briquettes per hour.

The following description of the plant at Clifton has been furnished by the company. In design the press is similar to the one used by the Geological Survey fuel-testing plant at St. Louis. This was designated the "English" machine, and has been described in the reports of those tests.†

The coal or coke fines are fed from the bins into the boot of a bucket elevator, which discharges them into the hopper at one end of a mixer, where it is mixed with pitch that has previously been broken in a pitch breaker into pieces of one-half inch maximum size. The quantity of pitch found to give the best results is about 8 per cent. From the mixer the material is sent into a disintegrator, which thoroughly pulverizes the coal and pitch into grains of 2 millimeters size or less. It is then elevated and passed into a heater, where it is subjected to the action of live steam, which gives the pitch sufficient fluidity to bind the other ingredients. From the heater the material drops into a pug mill which, while stirring the mass, sweeps it into a false bottom. This false bottom is behind the disk of the briquetting machine, and at each revolution of the main shaft the material is rammed into a pair of compartments in the disk. The disk contains eight pairs of such compartments, and at the same time that a pair of briquettes is being rammed into the disk on one side another pair is being compressed on the opposite side, while a third pair is being pushed out from the top of the disk onto an endless-belt conveyor, which delivers the briquettes to the side of a railroad car in front of the building. The briquette disk is made to revolve intermittently in eight periods to each complete revolution. During the pause in each period the three operations referred to take place simultaneously.

The capacity of the plant is 25 tons per ten hours. It is arranged to mix three ingredients into material for briquettes, but at present only coal or coke fines and pitch are used. The briquettes are rectangular in shape and weigh approximately four pounds each.

MICHIGAN.

The Semet-Solvay Company, of Syracuse, N. Y., has recently completed the construction of a briquetting plant at Del Ray, Mich., to be operated in connection with the by-product coking ovens and chemical works installed there several years ago by the same company. The installation of the briquetting plant was begun about two and a half years ago. As originally constructed the briquetting machine was a reciprocating press of English make, but after carefully working out the process the company came to the conclusion that a press of the reciprocating type is adapted only to large briquettes, whereas the domestic trade of the city of Detroit, for which this product was intended, demands a small briquette. As the result of the experience gained with the English machine, the company has developed a process for the manufacture of small briquettes, and, although this plant is just beginning operations, it gives excellent promise.

The process consists, essentially, of the intimate mixing of finely powdered pitch of proper quality and consistency with pulverized coal, so that theoretically each particle of coal is coated with the fine pitch. The mixture is then brought up to the proper temperature with steam, or steam and hot water, and is fed to a rotary Mashek press built by the Traylor Engineering Company, of New York. The output of the plant is from 10 to 15 tons of briquettes per hour. They are from 2½ to 3 ounces in weight, and about 1¾ inches square, shaped somewhat like a miniature sofa pillow. This shape is satisfactory for shoveling and for handling in household stoves and furnaces. The company is using a portion of coke breeze with the coal and pitch with a view of utilizing the breeze from its coke plant, and it is also experimenting on the best mixtures and the best grades of coal. The briquettes made so far are said to burn well and to give no smoke, except a slight puff when they are first thrown on the fire. As the plant is not yet in full operation, some minor adjustments are still being made to perfect the product, but the operators are much encouraged by results so far obtained, and expect within a short time to be making a thoroughly satisfactory commercial product.

NORTH DAKOTA.

During 1905 ex-United States Senator W. D. Washburn, president of the Washburn Lignite Coal Company, erected a small plant at Minneapolis, Minn., for experimental work in briquetting North Dakota lignite. The plant was too small to be operated successfully from a commercial standpoint. Several hundred tons of briquettes were made without the use of a binder. They proved a satisfactory fuel for domestic purposes and for stationary boilers, but were not adapted to locomotive use, as the heavy exhaust draft in the locomotive has the effect of disintegrating the briquette before combustion and causes the throwing off of large sparks.

Robert L. Stewart, also of Minneapolis, who is interested in lignite properties near Kenmare, Ward County, N. D., reports that he has been conducting a series of experiments with a view to briquetting this fuel, and as a result of his investigations the American Briquetting and Manufacturing Company has been organized. This company contemplates constructing, during the present year, a briquette plant in North Dakota convenient to the lignite deposits and having a capacity of 1,000 tons of briquettes per day. Mr. Stewart states that the briquettes can be manufactured at a cost not to exceed $2 per ton f. o. b., this cost including the expense of mining the lignite and delivering it to the briquetting plant.

TEXAS.

Three companies have been organized recently in Texas for the purpose of briquetting lignite, which occurs in great abundance through the eastern part of that State. These are the International Compress Coal Company, of Houston; the American Lignite Briquette Company, of San Antonio; and the Eureka Briquette Company, of Rockdale. The plant of the Eureka Company has been erected and is ready for operation at the time of writing this report, except for the fact that the drying apparatus has been found too small and the plant has been shut down pending the erection of a large drier. The details of the plant have not been obtained.

The American Lignite Briquette Company, while incorporated at San Antonio, will locate its plant at Rockdale, to be operated in connection with the lignite mines of J. J. Olsen & Son. The company has purchased a press made by the Klein Briquette Company, of St. Louis, Mo., and the plant will probably be in operation by the time this report is ready for distribution.

The International Compress Coal Company has been negotiating for the construction of a plant, but no actual building had been begun at the time of writing this report. All these plants expect to use asphaltic pitch made from heavy Texas oil.

FLORIDA.

In September, 1905, the Orlando Water and Light Company, of Orlando, Fla., completed the installation of a plant for the treatment and briquetting of peat, which occurs abundantly in the low-lying lands of Florida. The plant is located about three miles from Orlando, on the border of a peat bog from which its supply is drawn. As originally installed, this plant consisted of a macerating machine or pug mill, in which the fiber of the peat is entirely destroyed, and a brick press. The briquettes as they came from the press were about the size of an ordinary building brick, but when dried in the sun shrunk to about one-fourth their former bulk and lost from 75 to 85 per cent in weight. The briquetting feature of the plant was abandoned in the summer of 1906, as it was found that this part of the work represented 75 per cent of the total cost, and that a satisfactory fuel could be made without briquetting. The method of treatment at the present consists simply of "machining" the peat in the pug mill and dumping it in masses of several hundred tons. As the peat dries it shrinks and cracks into large, irregularly rectangular blocks, which are broken off from the heap and stored. When thoroughly dried, these blocks make a good hard fuel, which it is stated may be used for both locomotive and stationary boilers, for household purposes, and for the manufacture of gas. Tests of the machined peat for producer gas at the Geological Survey fuel-testing plant gave excellent results.*

The machine used at the Orlando plant was built by the Moore & Wyman Elevator and Machine Works, South Boston, Mass., under patents issued to the late T. H. Leavitt, of Boston.

MISSOURI.

During the summer of 1903 Governor W. C. Renfrow, of Oklahoma, became financially interested in a briquetting company in St. Louis. In the fall of the same year E. D. Mizner, of Hamilton, Ontario, visited St. Louis to make a report for some Canadian interests relative to the purchase of the Canadian rights for the patents of this company. The results of these investigations, and the efforts of Governor Renfrow to force the briquette company to deliver a machine, ended in the bankruptcy of the company. In October, 1903, an agreement was made between Governor Renfrow and Mr. Mizner by which Mr. Mizner was to build a briquette machine which would overcome the difficulties encountered with the other press. No company was organized at that time, but contracts were drawn satisfactory to the people interested.

The following spring Mr. Mizner built the first Renfrow press, which made briquettes 2 inches in diameter, weighing about four ounces. This press had some of the essential features of the original Renfrow press, but made briquettes only at the end of the stroke—that is, twelve briquettes per revolution. After this machine was built it was discovered that the briquettes were too small and that the construction of the machine was too light. Mr. Mizner also developed the idea of making briquettes at both ends of the stroke, thus doubling the capacity of the machine. It was decided to build a much heavier machine, making a briquette 3 inches in diameter. Changes were also made in the method of mixing and heating the material. The cast-iron vertical heaters of the original press were supplanted with horizontal jacketed heaters, using ordinary spiral conveyor flights for mixing and handling the fuel. To this was added a short vertical, acting as a reservoir into which live steam was admitted just before the mixture was delivered to the molds.

This machine was completed in the fall of 1905. C. T. Malcolmson, of the Geological Survey testing plant,† inspected this press at the shops of the Ramming Machine Company, at St. Louis, and burned some of the briquettes under a boiler at that plant. Difficulties were developed from the fact that the fuel remained too long in the vertical heaters, and some trouble was also experienced in getting the material

* From a United States Geological Survey Bulletin.

† Bulletin of the United States Geological Survey, No. 261, and Prof. Paper No. 48, 1906.

* Campbell, M. R.: "Peat; Mineral Resources of the United States for 1905," United States Geological Survey, 1906, p. 1220.

† The briquetting portion of the Geological Survey coal-testing plant at St. Louis during the exposition has already been described in Bulletins Nos. 261 and 290, and Prof. Paper No. 48. After the close of the exposition the American machine, installed by the National Compressed Fuel Company, of Chicago, was removed, and early in 1906 the remaining portion of the briquetting plant was destroyed by fire. In rebuilding the plant provision was made for the installation of a Renfrow briquette machine.

from the die filler to the die proper. Occasionally briquettes would stick in the dies, resulting in a double charge, which finally crippled the machine. Provision was then made to overcome these difficulties and the machine was rebuilt. The new machine was first tested in March, 1906. The heating capacity was increased so that the charge remained in the conveyors about fifteen minutes before reaching the dies, thus allowing the material to become thoroughly heated and the melted pitch to mix with the coal. Brushes were added to insure the charge being carried to its proper position in front of the die, and an ejector, operated by a magnet, effected the delivery of the briquettes from the ends of the plungers. Many of the parts of the machine were strengthened and steel and bronze were substituted for cast iron in the wearing parts. The results of the tests on this machine made under the supervision of Mr. Malcolmson for J. A. Holmes, expert in charge of the Geological Survey fuel-testing plant, at the company's testing plant, resulted in a contract for the rental of this machine by the government. In May, 1906, the first successfully operating Renfrow machine was installed at the fuel-testing plant.

The results of the tests made on the Renfrow machine from May, 1906, to March, 1907, indicated that the design of this press was, in the main, satisfactory, and that the difficulties experienced were due almost entirely to bad or weak construction of the machine. This machine was the result of many changes, and it was impossible to strengthen some of the weak parts owing to the limited space, or to the fact that the size of the part was fixed by the original design.

The difficulties encountered in operating this machine at the fuel-testing plant soon indicated its weaknesses, and as a result the Renfrow Company designed and built two new presses, one of which was installed and is now being operated by the Western Coalette Fuel Company at Kansas City. The other is now ready for delivery to the government fuel-testing plant at the Jamestown exposition. The new press makes a briquette 3¼ inches in diameter, weighing about a pound. The machine which was operated at the St. Louis fuel-testing plant could not be depended on to deliver more than 1,000 pounds pressure per square inch on the briquettes without seriously straining the frame of the press. The new machine will deliver a maximum pressure of about 2,500 pounds per square inch without straining. All the wearing parts not under pressure are made of bronze, so as to prevent corrosion; the dies are made of case-hardened steel and, owing to the abrasive action of the fuel, are kept clean and bright. The cams and rollers, which were originally made of chilled cast iron, are in the new machine made of case-hardened tool steel, and the design of the housing has been so changed that any of the parts can be removed without dismantling the machine. Provision has also been made to so feed the heaters that they will always run clean and at the same time keep a full load in the chamber above the die filler. This chamber, closed in the old machine, is open in the new, thus allowing the operator to regulate the supply of fuel to the press at all times. The plungers are arranged so as to make it practically impossible for a double charge to enter the press, and the length of the spring behind the plungers has been increased so that a double charge would not affect the press in any way.

Early in 1906 the Renfrow Briquette Machine Company was incorporated under the laws of the State of Missouri, with a capital of $1,000,000. W. C. Renfrow is president, J. M. Smith secretary and treasurer and E. D. Mizner superintendent, and it is a close corporation. The company will not offer for sale any machines until after the Kansas City plant has proved successful. So far as can be learned, the construction of the Kansas City plant was brought about by the willingness of J. H. Durkee, president of the Western Coalette Fuel Company, to accept a Renfrow machine without a guaranty, simply on the strength of the work done at the fuel-testing plant. There are still, of course, some difficulties to be overcome, as is the case in the operation of any new plant, but in the main the mechanical operations of this plant are satisfactory, and the Renfrow Company has been able to deliver what it contracted to deliver. Financial difficulties have threatened the life of the plant under the present organization, but Governor Renfrow has stated that he will not allow this plant to fail for this reason. A contract has been signed to deliver one of the machines to a company at Detroit, but under the terms of the contract no date is fixed for the delivery of this machine, and no guaranty from the Renfrow Company has been required. Governor Renfrow is also authority for the statement that the Detroit machine will not be delivered until after the Kansas City plant has been successfully operated and put on a commercial basis.

The Renfrow Briquette Machine Company has no plant of its own, but has under serious consideration the establishment of a factory at St. Louis. All the machines above mentioned were built by machine shops under contract. The Kansas City machine was built by the Excelsior Tool and Machine Company, at East St. Louis, and the other machines by the Ramming Machine Company, of St. Louis.

COST OF MANUFACTURE.

The cost of manufacture of briquettes at one of the plants in the State of New York is as follows:

Pitch:		
6 per cent of pitch, at $10 per ton		$0.60
Deducting for increased weight of product due to pitch, calculating product at $5 per ton		.30
Net cost of pitch		$0.30
Fuel:		
For boiler, broken coal and screenings; broken briquettes, 4 tons per day of 10 hours, at $2.50 per ton = $10; per ton of briquettes		.10
For heaters, driers, and pitch melting; 3 tons, at $2.50 per ton = $7.50; per ton of briquettes		.075
Labor:	Per day.	
1 foreman	$5.00	
2 pitch melters	3.50	
1 dust bin man	1.75	
1 engineer	3.50	
1 man on second floor	1.75	
1 man on ground floor	1.75	
1 night watchman	1.75	
1 oiler	1.75	
	$20.75	
Per ton of briquettes		.21
Miscellaneous:		
Wear and tear per ton of briquettes		.10
Lubricating oil per ton of briquettes		.01
Insurance per ton of briquettes		.005
Interest on capital invested—$40,000 at 6 per cent		.10
Office expense, telephone, stenographer, and stationery—$2,000 per annum		.09
		$0.99
Anthracite dust at $1.40 per long ton, per net ton of briquettes		1.25
Total cost of briquetting		$2.24
Rebriquetting 3 per cent of breakage and abrasion, charging it back to plant as dust, per ton of briquettes		.06
Net cost per ton of briquettes		$2.30
Wholesale selling price in bin		4.80
Net profit per short ton		$2.50

METAL WASTES.

By DR. THEODOR KOLLER.

IN order to separate mixed chips, it was once the practice to remove the iron and steel fragments by means of a magnet, held in the hand, the brass waste being left behind.

For the curtailment of this tedious task, the French engineer Vavin has designed a machine, which has already demonstrated its practical value.

This machine consists of two superimposed cylinders, turning on their axes, the outer circumference of which is provided with adjacently placed alternate hoops of soft iron and copper. Each iron hoop is suitably connected with a series of horseshoe magnets so disposed that one pole of the magnet is connected with one iron hoop, the other pole with the one next adjacent to it. The admission of the metal chip mixture to be separated is effected by means of a hopper, with a shaking shoe, from which they descend in a stream almost equal to the breadth of the cylinder. The iron chips are attracted to the magnetized iron hoops of the cylinder and carried around with it until a revolving brush wipes them off into a special receptacle. The brass chips, and a portion of the mixture of the two metals, fall onto the second drum, the construction of which is the same as the upper one. Only the alternate iron and copper rings, as opposed to the upper cylinder, are so placed as to be directly contrary to it in the vertical plane, the opposed metal rings being always different. While the brass chips fall down directly, the separation process is completed, the iron particles retained by the rings being carried around to the other side where the brush scrapes them into the iron-chip holder. The machine can be operated by hand or by transmitted power. It occupies only a space of 2 feet 6 inches by 14 inches in area and is 5 feet 3 inches high.

In the London and North-Western Railway Company's shops at Crewe, the same object is attained in a very simple and economical manner by a melting process. The mixed iron and brass boring chips and the slag from brass casting are mixed with limestone, powdered coal and oxide of iron or forge scale and this mixture is subjected to smelting; the brass settles to the bottom from the fluid slag and is separated in the form of ingots.

ALLOY WASTES FOR THE PRODUCTION OF BRONZE COLORS.

In the manufactories of imitation gold leaf, the waste which results from the rolling and hammering of the alloy is utilized. According to the old process, the waste resulting from the manufacture of imitation leaf gold (the parings) is rubbed down with honey or gum solution, on a rubbing stone, until a metallic mass is obtained. The resultant paste is placed in water to dissolve the binding agent or adhesive material and the metallic powder, after drying, is subjected to the so-called oxidization process.

For this purpose the dry powder is mixed with some fat, placed in a pan, and the mixture heated over a fire until the required shade has been obtained. Nowadays, this process has been greatly accelerated by the employment of machinery, and especially for certain kinds, the colors of which can be obtained without oxidization, by smelting the metals together in the proper proportions. The alloys are beaten, by steam-driven hammers, into the thinnest possible leaves and these transformed into powder by placing them in a fine, iron-wire sieve and rubbing the metal through the mesh by means of a scratch brush. This rubbing through is effected with the aid of oil and the substance issuing from the sieve passes into a peculiarly constructed rubbing machine, in which the metal particles are rubbed down exceedingly fine. The rubbing machine is so constructed that over one steel plate another revolves that is closely set with fine, blunt-pointed steel needles.

The alloy is now in the form of a very fine powder that is mixed with oil; the mass is first placed in water, when the greater portion of the oil is separated on the surface and the metal mass that subsides to the bottom is subjected to the pressure of a very powerful press, by means of which nearly all the oil is removed.

The variety of colored bronze known as "brocade" consists of somewhat larger particles of alloy, which are made from the trimmings by means of reduction in a stamping apparatus, the unequally large particles being subsequently separated by screens and then by a current of air. A certain variety of "brocade" consists only of particles of mica waste, reduced to a fine powder. Some kinds of bronze are colored with the aid of aniline dyes, this being effected by pouring over the finely comminuted powder a solution of aniline color in strong alcohol and rubbing the solution down intimately with the metallic powder; in this case, however, only dilute solutions of the aniline colors must be employed, otherwise a uniform mixture of the mass will be attainable only after very long rubbing.

UTILIZATION OF THE WASTE OF "LEONIC" WIRE FACTORIES.

The so-called "leonic" wire is made of the finest and purest copper. There are copper, cemented, silver, and gold wires. The first have no coating. The cemented wire has a coating of brass produced by exposing the copper rods in a furnace to zinc vapors. The silver wires are coated with pure silver; the gold wires, over the silver coating, have a further coating of gold. The flat pressed wires are called flats or tinsel. When these wires are heated to redness the coating disappears, it escapes into the surface and the appearance is produced of an oxidized copper wire. This wire, placed in glass tubes and reduced in a current of hydrogen, shows the most beautiful copper color. The wastes of fine silver wire or silver plate, according to Dr. E. Ebermayer, can be admirably utilized for elementary analysis. These fine residues are very soft; they completely fill the tube and readily allow the passage of the current. Cemented plate, in consequence of the zinc it contains, is of course excluded; for this purpose, only silver wire can be used. The coarser numbers, also spoiled silver tinsel and heavy bullion, may be employed for the development of sulphurous acid and at the same time the silver can be recovered.

UTILIZATION OF THE WASTE OF ELECTRIC BATTERIES.

From the zinc solution we first separate the copper by the suspension in it of zinc clippings, and the clear colorless filtered fluid can either be precipitated with lime milk, thereby obtaining a good, serviceable zinc white, rich in gypsum, and of fair covering capacity, which is especially adapted for use as a water color in wall-paper printing and in interior painting, or the solution is boiled with a certain quantity of common salt and we obtain a fine Glauber salt, for glass manufacturing, which is not injured by a small quantity of zinc, and chloride of zinc, which is valuable for the impregnation of building timbers and sills and for the production of an artificial marble as well as for a lime cement.

The concentrated zinc solution, if highly heated, gives off sulphurous acid (valuable for bleaching) and hard zinc oxide, which is admirably adapted for polishing.

The copper solution is always too weak to be worked for copper salts, and therefore it is best to precipitate the copper with zinc, in order to obtain it as metallic sponge.

To recover copper from the salt, the copper sponge must be collected as well as the copper granules. Boil

them out twice with pure water, mix them with wood charcoal, five per cent of soda and one per cent of borax and melt at a sharp wood charcoal heat to obtain a regulus.

To recover metallic zinc from the zinc solutions, evaporate them with 10 per cent of hard coal powder to dryness and calcine it in recumbent retorts, after which we proceed as in zinc smelteries, i.e., we distill it.

UTILIZATION OF NICKEL WASTES.

To turn the waste of rolled and cast nickel anodes as well as nickel sand that gradually collects at the bottom of the boxes to useful account, proceed as follows: The wastes are washed repeatedly with hot, clean water, then boiled in dilute sulphuric acid—1 part sulphuric acid to 4 parts of water—until pure water, poured over the waste, is no longer made turbid. Hereupon the waste, or the sand, is allowed to dry completely, and it is then transferred to concentrated nitric acid. At this stage great care must be exercised and large porcelain vessels must be used to prevent boiling over of the solution. As soon as the solution begins to crystallize, add some clean water to it and heat it. Care must be taken that the solution of nickel in nitric acid contains as little free acid as possible. The nickel nitrate obtained must be dissolved in hot distilled water and the solution neutralized with purified caustic potash, which must be carefully and gradually added, after which the mixture must be filtered with care. The nickel bath obtained in this manner works direct on all metals and gives a close, silvery white nickel deposit.—Translated from Verwertung von Abfallstoffen aller Art.

ELEMENTS OF ELECTRICAL ENGINEERING.—XIV.

ALTERNATING CURRENT GENERATORS.

BY A. E. WATSON, E.E., PH.D., ASSISTANT PROFESSOR OF PHYSICS IN BROWN UNIVERSITY.

Continued from Supplement No. 1681, page 184.

A DYNAMO for generating alternating currents is usually distinguishable from one of the direct current sort by the absence of a commutator, and by its numerous field-magnet poles. Still, some instances will be considered in proper place, in which there may actually be a commutator or only few poles. A feature in which there is little danger of confusion with direct current apparatus is the now common practice of having the field magnet of the alternator the revolving member. It can easily be seen that the other class could with only great difficulty in mechanical construction, and with no mitigating advantages, provide for a revolving field-magnet rather than a revolving armature. Commutation is effected by means of stationary brushes that momentarily connect with coils passing through the "neutral" point; if the armature and commutator were stationary, the brush holders and their fastenings would have to revolve, yet with provision for shifting the position of brushes to prevent sparking, also with rings and sliding contacts for delivering the current to the exterior load.

While many of the early alternators imitated the direct current style of construction, and had revolving armatures, some of the very earliest, notably those built by Gramme for operating Jablochkoff candles, and later those by Mordey, had revolving fields. It is also worth noting that, except in detail, Gramme's original construction is not essentially different from the present approved design.

While it is quite possible to use an ordinary ring or drum-wound armature for alternating currents, it is not customary, except in case of "rotary converters," to adopt it. The ring armature has too much self-induction to allow good regulating qualities for the usual constant potential work, and the simple drum does not allow for generating a sufficiently high electromotive force. The rotary converter is a relatively low potential machine. The sphere of alternating currents is in long distance transmission, and for securing the desired high potentials a large number of conductors must be connected in series. For a simple case, the various groups of conductors must be acted upon by their neighboring poles all at the same instant. To accomplish this a distinctive type of winding has been devised, often called "pole" type. A description of an actual machine will make the matter clearer. Fig. 57 represents the construction common in about 1888. This is a Thomson-Houston machine of 35 kilowatts capacity—closely copied from the earlier Westinghouse pattern. It has a smooth-core armature acted upon by a field magnet of 10 poles; a direct-current machine of 3 kilowatts capacity, for energizing, or "exciting," these poles, therefore commonly called an "exciter," is shown, at the right hand, driven by a small belt. Sometimes the exciters are directly connected on the main shaft, and in other cases they are entirely independent machines. Independence is usually desirable, for if by variation of speed there should be some fluctuation of potential, the change will not then be exaggerated by the variations of the exciter.

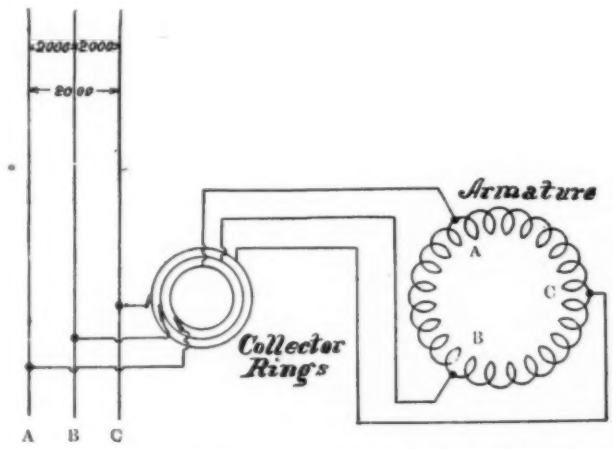


Fig. 58.—Connections for Three-Phase "Delta" (Mesh) Revolving Armature.

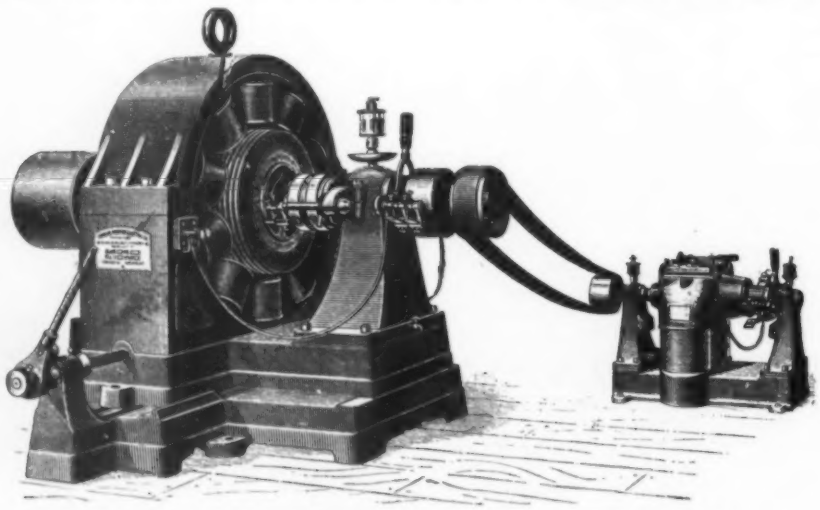


Fig. 57.—Alternating Current Generator and Its Exciter. Type of 1888.

The armature shown is about 18 inches in diameter, and 10 inches in length under the poles. Ten strips of fiber, 10 inches long and ⅛ inch thick, are pinned lengthwise to the core, equidistant, and serve to locate and drive the electrical conductors. These consist of single layers of rectangular wire, wound like flat elongated shuttles, of perhaps 20 turns each. Being so thin and flat, they were commonly designated as "pancake" coils. They are connected in series, first two inside ends, then two outside ends, etc., and except for the interposition of a commutator for assistance in regulating the potential, the final ends were led to the "collector rings," shown between the bearing and the armature. The commutator is shown just outside the bearing, with adjustable brushes, as is usual for direct-current machines. The function and construction of this adjunct is, however, a little peculiar, and well worth examining. Though apparently of ten segments, to equal the number of poles, there are really but two segments; two castings of five prongs each are slid together, much as the fingers and thumbs of the two hands might be placed, and one terminal of the armature winding is led through a hole in the shaft to one of these castings, while another wire passes from the other casting to one of the rings. The other armature terminal connects directly with the second ring. Commutation is effected in the same manner as with an ordinary two-segment commutator, as used with a Siemens shuttle armature, but with the only difference that the two segments are subdivided and interspersed to accommodate the increased number of field poles. Since half the number of poles is an odd number, diametrically opposite points will be proper places for the brushes, as is the case with a bipolar direct current dynamo. Several other positions would, however, be equally allowable, as long as the two brushes touched the two different castings. Had the field an even number of pairs of poles, say eight poles, opposite points of the commutator would be on the same casting, so some unsymmetrical location of brushes would be necessary. The regular machines of this type had 10, 14, and 22 poles, therefore in each case the brushes were placed opposite.

Two different windings are on the field cores, the greater part supplied with current from the exciter; the other part is fed with the temporarily rectified current from the main armature. It is recognized that this gives a sort of compound winding, the separate excitation corresponding to the shunt, and the self-excitation to the series portion. At no load, there will be just enough magnetization to give the normal voltage; as the load increases there will be a somewhat increased strength of field, to allow for various inevitable losses. In order to have a term to cover this particular style of excitation, Prof. Thomson denoted it as "composite." With incandescent lamp loads, the scheme was very successful and popular with station managers. Since the only difference of potential between the two segments was that due to the ohmic resistance of the series portion of the field winding—say 5 or 10 volts, while between the rings there was 1,000 or 2,000 volts—there was an almost entire absence of sparking. When combined with motor loads, however, which with every change of load gave a different angle of lag, and required a different position of brushes, the scheme had to be abandoned, and reliance for regulation placed upon better design, with simple manipulation of the strength of the exciter field.

The standard speed for this size of dynamo was

1,500 revolutions per minute. From the definition that the number of "cycles" equals the number of pairs of poles multiplied by the number of revolutions per second, it is found that the "frequency" (cycles) is 125. The Westinghouse Company drove a similar machine at a normal speed of 1,600 revolutions, resulting in a frequency of 133. Both these figures are known as the old high frequency.

With the introduction of "ironclad," or toothed armatures, with T-shaped teeth, the output of the 35 kilowatt machine was increased to 60 kilowatts, but with such a rise of temperature in the solid cast iron of the field magnets that laminated cores became imperative.

By 1890 the means had been discovered of satisfactorily operating motors on alternating currents, and lower frequencies than usual for lighting purposes were desirable. Added to this requirement was the desire to get the speed low enough to admit direct coupling of armature to steam engine. Such a frequency was sought as would allow for the operation of all classes of service—incandescent and arc lamps and motors. Arc lamps do not work well at less than 40 cycles, so to be safely removed from that limit 60 was selected as a good figure. In Europe, however, 50 was adopted, and American engineers are now inclined to admit that that is rather the better frequency. The Westinghouse and Thomson-Houston Companies each built a 375-kilowatt 80-pole, 90-revolution dynamo for an electric lighting company in Providence, R. I., at this time, which were the first of their kind. In recent years these have been fitted with new armatures of the three-phase sort, with an increase of rating to 525 kilowatts.

For ordinary electric lighting, simple armature windings with a single circuit, and denoted as "single-phase," are sufficient. Motors, however, especially those of considerable size, require an orderly succession of currents, such as to give a progression to the magnetic flux, in the direction of rotation, and at no time to leave the machine without some working force. If, in addition to the winding required for a single-phase circuit, other sets of similar coils were placed midway, the terminals connected to two additional rings, making four rings in all, first one circuit would be energized, then the other, the current dying out in one while it was rising in the other, and when one was generating its maximum the other would be at its zero value. The analogy of a two-crank engine—a locomotive, for instance—makes the idea clear from a mechanical point of view. If three sets of coils were employed, so that when one set was directly under the poles, and therefore in the most active position, another had just gone by that position, while the third was approaching it, there would result the "three-phase" circuit. The three sets of coils would give six ends, and apparently require as many collector rings, but by joining three of the ends at once together, or by letting the end of one set be the beginning of the next, only three rings are actually needed. The three-cylinder engine—say of the marine type—suggests how the maximum and zero values of the different current waves follow each other.

Ordinary direct-current dynamos can be made into alternators of any desired number of phases, by substituting rings for the commutators, connected to appropriate points of the winding, or temporarily, by slipping rings over the commutators. A thin wooden shell, or sheet of fiber or mica, could first be placed on; then for a single-phase two rings could be used; and by means of a headless set-screw in each, connection could easily be made in case of a two-pole field with the two segments directly opposite. If enough of the commutator was still exposed, the machine could be self-exciting, and even for the delivery of direct current in addition to the alternating. Of course, the sum of these two currents should not exceed the regular ampere capacity of the winding. By use of three rings connected, respectively, to three equidistant segments, three-phase currents would be available, while four rings—the pair belonging to each circuit being connected to opposite segments, but only one-quarter of the winding intervening between the two circuits—will allow for two phases.

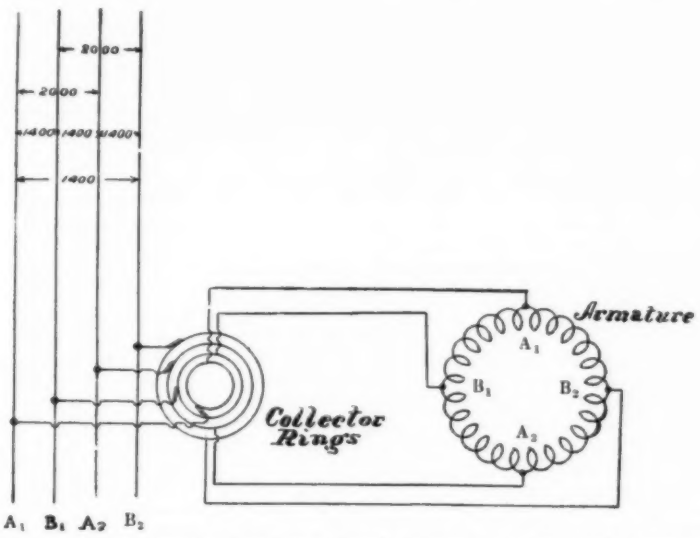


Fig. 59.—Connections for Two-Phase Closed Circuit (Mesh) Revolving Armature.

Reference to Figs. 58 and 59 will make the idea entirely clear. Ring armatures of the revolving type are here diagrammatically represented, with their collector rings and brushes. Taps are led out at three equidistant points in one and at four points in the other, and connect with the exterior circuits of three or four wires. No confusion must be made between the genuine three-phase wiring and the familiar Edison "three-wire" system; it is true that each uses three wires, but in the former all three wires are supposed to carry equal currents, therefore are of the same size and equally important; in the latter it is aimed to have the middle one "neutral," or idle, and in case of a balanced load it carries no current at all, and is often of smaller size than the other two. Again, in case of the three-wire system, there is twice the voltage between the outer wires that there is between either of these and the neutral; with the three-phase there is the same voltage between any pairs of wires. This condition is emphasized in the diagram, where it is represented that there is a difference of potential of 2,000 volts in all three phases. With the two-phase winding, opposite points A and A_1 belong to one phase, while B and B_1 serve for the other. Since diameters drawn through these points would be at right angles to each other, the two circuits are sometimes described as being in "quadrature" with each other, and frequently called "quarter-phase," as well as two-phase.

If three straight lines should be drawn to connect the points A, B, and C of Fig. 58, they would form an equilateral triangle, or the Greek letter "delta"; this designation is a very convenient one, and this style of winding, with drum rather than ring armatures, and multipolar field-magnets, is used for almost all generators and motors not exceeding 2,000 volts in working potential. It is imperative for rotary converters, or there would not exist the opportunity to connect the same winding to the many segments of the commutator.

The two-phase winding shown in Fig. 59 is also an interconnected, or "mesh" arrangement, hence, if desired, current could be taken from points adjacent rather than opposite to each other. If there is a difference of 2,000 volts between A and A_1, there will be about 1,400 volts between A and B. This can readily be proved by drawing the diameters, and connecting the points A and B with a straight line; this becomes the diagonal of a square, in length equal to fourteen-twentieths of the diameter. Geometrical and not arithmetical solutions must be given to all combinations of alternating electromotive force.

For high potential three-phase generators it is customary to have one connection in common between the coils and to lead the other three ends to the outgoing terminals. This is graphically designated as the "Y" winding. A Thomson-Houston arc dynamo can be readily changed into an alternator of this sort by substituting three rings for the three regular commutator segments. Of course the field magnet would then require separate excitation. The common connection is really a neutral point, and a fourth ring could be connected to it if desired. This is a method sometimes adopted in central station operation—i. e., to operate motors from the three main wires, but to tap single-phase transformers between any one of these and the neutral. For assisting in protection from lightning, this neutral can be grounded, without danger of throwing the system out of balance. To see such a machine, one would easily mistake it for a "two-phaser," and a careful scrutiny of the switchboard arrangements might be needed to reveal the real conditions.

Conversely, a two-phase machine can get along with only three wires. In this case, the two circuits would have one wire in common, and this ought to be of twice the section of the others. The two phases are, however, preferably kept separate, and such joint use of a wire reserved for cases of breakdown.

With the adoption of increasingly higher voltage, it was deemed imperative to provide for personal safety, as well as to improve the general reliability of the apparatus, by eliminating the alternating current from the collector rings. By letting the armature be the exterior member, and stationary, larger slots and thicker insulation could be used; larger spaces for the circulation of air were possible, and the connections could be led from convenient points in the winding, inside the frame of the machine, quite out of sight and reach, to the switching devices. Being free from the jarring and vibration common to rotating bodies, the conditions were made favorable for preservation of the insulation. The field-magnet is now usually made to consist of laminated poles mounted on the rim of a cast iron or steel wheel, often of sufficient weight to serve also as a balance wheel. The winding, instead of being of ordinary round, insulated wire, is made of bare copper ribbon, say 1/32 inch to 1/16 inch in thickness, and 1 inch to 1¼ inches in width, wound on edge. Special tools involving considerable ingenuity have been devised for this operation, and have contributed in no small degree to the success of this type of machine. Of course the iron poles are properly insulated with paper and mica, these flat coils slipped in place, their separate convolutions now insulated with paper, but with the exception of the paint the outer edges are left quite bare,

Fig. 60.—Revolving Field Magnet (40 Poles) for Alternating Current Generator.

Fig. 61.—Stationary Armature Winding for Three-Phase Generator.

When revolving, the field-magnet stirs considerable air, resulting in generous cooling of these outer edges, but the cooling effect is readily communicated to the inner portions of the conductor. It is seen that with ordinary wire, the act of cooling the outer layer would have much less effect on the bottom layers, separated by considerable accumulation of insulation. Practically, the result is that about twice as much current can be sent through ribbon-wound coils as through those of the other sort. Two insulated rings are needed on the shaft of the machine, to serve as terminals for this winding, upon which brushes rest, and conduct the direct current for the excitation. It is seen that however high may be the potential for which the armature may be wound, the field may still be energized from any desired low potential source. 110 is the most common voltage used—a potential regarded by dynamo tenders as a plaything. Copper rings and brushes are to be expected in such places, but cast-iron rings and carbon brushes make a surprisingly durable combination.

Fig. 60 shows a 36-pole field magnet of the particular construction which is standard with the General Electric Company.

It is rather difficult to give an adequate idea of the exact armature winding for large alternators. The student must needs have reference to complete diagrams, and supplement such inquiry with investigation of the machines themselves. The windings were really first used on motors, then recognized as eminently fitted for generators also. Under the topic of alternating current motors to be considered in the next two chapters further opportunity will be afforded to give insight into these matters. In general, it may now be said that the coils can follow either of two general schemes, one closely imitating the formed coil winding used with direct current drum armatures, and called the "distributed" or "polyphase" type, and the other—quite distinctive to its class—made of rectangular coils that surround or pass through one another. A representation of this latter arrangement is given in Fig. 61. In order to approach the excellence of wave-form given by the other type of winding, the several coils are made double, or with "two coils per pole per phase." The winding is for three phases, and from the appearance of the ends is often called the "chain" type. Proper spacing of the poles to fit this winding is given by the figures 1, 2, 3, and 4. Inner and outer coils of each pair are wound in the same direction, as if one were a mere continuation of the other, but the coils 1-2 are connected in the opposite direction with the pair 3-4, the next ones of the same phase. The same scheme would continue around the entire circle, embracing one-third of all the coils, while the rest would be connected in two other but similar circuits. Finally, for ordinary potentials, the six terminals might be connected in a delta arrangement, or for higher potentials, in the Y manner. The same coils connected as a Y will give a terminal voltage 1.73 times as much as the delta. The latter has, however, 1.73 times the ampere capacity of the other, thus the capacity in watts is properly the same for both types. By reason of the relatively fewer slots, greater thickness of insulation can be allowed than with the distributed type, and this, together with the freedom from actual contact of the various coils, makes the possibility of winding armatures of 6,000, 13,000, and even 30,000 volts. In such cases, the insulation may be of mica ⅜ inch in thickness. By winding the generators directly for such potentials, the first cost and continual losses in transformers, that would otherwise be necessary, are saved.

A peculiar construction of alternator, not particularly favored by engineers, is known as the "inductor" type. It has no moving wire at all, the field coils, like those of the armature, being supported on the stationary part of machine, while chunks of laminated iron alternately make and break the magnetic circuit. The principal defect seems to be due to excessive magnetic leakage, with consequent poor regulation, especially with motor loads.

Two-phase armatures are made in the same manner as shown in Fig. 60, by employing only two sets of coils, and having such a number of slots that one set will overhang or embrace one-half the breadth of the other. As to the relative qualifications of the two-phase as compared with the three-phase circuits, engineers are somewhat divided in opinion. There are various grounds of preference or economy. The latter requires a rather more careful balancing of "feeders" than the other, so sometimes the two-phase is selected for purposes of local distribution. The three-phase transmission, however, requires only three-quarters as much weight of copper as the other, hence for long-distance transmission, with the added gain in saving one line of insulators, there is seen the reason for the general adoption of this system. For the same weight of materials, the two-phase generator has the advantage, for a slightly greater output can be obtained. Many instances can be found, notably in the case of the Niagara installation, where two-phase generators are used, with transformers that, while stepping up the potential, also change the currents to three phases. Economy of both generation and transmission is thereby secured.

THE NATURE OF TRUE BOILER EFFICIENCY.*

FORMULATED LAWS GOVERNING THE RATE OF HEAT ABSORPTION.

BY W. T. RAY AND HENRY KREISINGER.

THE Steam Engineering Division of the United States Geological Survey, in conducting boiler tests for the purpose of determining the heat values of coal for steaming purposes, found early in its experiments that the results obtained would have but little meaning unless the boiler performance were subtracted or divided out so as to get the efficiency of the grate and furnace. The purpose of this article, which is largely an abstract from a bulletin prepared by the above-named division, is to offer a few formulated laws governing the rate of heat absorption by boilers and to present the more important results of these experiments.

Heat travels from any hot body only to bodies at lower temperature, therefore, any boiler can absorb only that heat which is above the temperature of the water in it; heat below this temperature will not flow into the boiler water and therefore is not available for absorption. Commercial boilers absorb only part of the heat which is available for them; the percentage of the available heat which is absorbed by the boiler is called the true boiler efficiency. This efficiency depends somewhat on the way the heat is presented to the boiler, but chiefly on the construction of the latter. The true boiler efficiency is then defined as the ratio of the heat absorbed by the boiler to the heat which is available for it, counting only that heat available which is above the temperature of boiler water.

In any steam-generating apparatus the heat is evolved by the burning of fuel in the furnace, and is then transmitted through the space and through the water heating plates into the boiler water. The path of the heat travel and the mode of the transmission are shown in the accompanying diagram.

In practice the water heating plate of the boiler is always, to some extent, covered on the outside with a coating of soot, and on the inside with a layer of scale or mud. Just on the outside and entangled in the small recesses of the soot coating, is a dense film of gas which adheres to the solid. The density of this gaseous film decreases outward from the solid layer of soot. It is somewhere within this gaseous film where the dry surface of the water heating plate can reasonably be assumed to exist. There is a similar film of steam and water, adhering to the layer of scale on the inside of the boiler, which film can be considered to contain the wet surface of the heating plate.

In the diagram it is shown that heat is communicated to the dry surface of the water heating plate mainly in two ways:

a. By radiation from the hot fuel bed and furnace walls.

b. By convection from the moving gaseous products of combustion. By convection is meant here the process of displacing cold molecules from the adhering film of gas by hotter ones from the moving mass of hot gases.

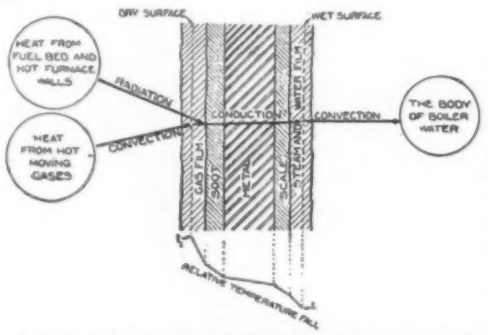


DIAGRAM SHOWING THE PATH OF HEAT TRAVEL FROM SOURCE OF HEAT TO BOILER WATER.

From the dry surface of the heating plate, the heat is transmitted through the layers of gas, soot, metal, scale, and steam to the wet surface purely by conduction. From the wet surface the heat is carried into the body of the boiler water mostly by the convection of the circulating water. The retardation of any one of these three modes of heat travel lowers the efficiency of the boiler.

It has been said that the dry surfaces of the water heating plate may be considered as being somewhere in the adhering film of gas. This statement is more correct when it refers to the heat communicated by convection than to the heat imparted by radiation. In the latter case the greater part of the heat passes through the gas film directly to the soot, because gases are to a great extent permeable to the radiant energy.

As the adhering films of gas and the film of steam and water may be, and very likely are, of considerable thickness, the heat must pass through part of the thickness of the film by conduction, and as both the gas and steam are very poor conductors of heat, the resistance which these films offer to the passage of heat may be even greater than the combined resistance of the soot, metal, and scale.

Although this paper is intended to discuss mainly the factors which influence the rate of heat impartation by convection, a brief explanation of the laws of the rate of heat radiation and the rate of heat conduction will help in making clear the whole matter of heat absorption by the boiler.

The quantity of heat which the boiler receives by radiation from any hot portion of the furnace or the fuel bed may be taken to be proportional to the difference of the fourth powers of the absolute temperatures of the hot parts of the furnace and the soot coating on the boiler plate. This law of radiation is known as Stefan and Boltzmann's law. Strictly speaking, it applies only to black bodies; however, within the usual temperature range of the boiler furnace it can be applied to boiler problems without any serious error. It shows that the quantity of heat received by the boiler by radiation increases very rapidly as the temperature of the furnace rises. In boilers where the heat received by radiation is a predominant part of the total heat absorbed, the true boiler efficiency necessarily increases with the rise of the furnace temperature.

The quantity of heat which can be transmitted through a given unit of water heating plate in a unit of time depends on the difference of the temperatures of the dry and the wet surfaces of the heating plate, and the conductivities of the substance between the two surfaces. For instance, if it is required to transmit double the quantity of heat in the same length of time, the difference of the temperatures of the two surfaces must be doubled. Since the temperature of the wet surface is nearly the same as that of the steam in the boiler, and therefore cannot be lowered, the temperature of the dry surface must be raised; as it is this dry surface of the heating plate which cools the furnace gases, the rise of the temperature results in the rise of the temperature of the escaping gases. Thus we see that with the same conditions of the heating plate and the same initial temperature of the furnace gases, the temperature of the escaping gases will rise with increasing capacity, thereby decreasing the efficiency of the boiler in corresponding degree.

The main cause of unnecessarily great differences between the temperatures of the dry and wet side of the plate and the consequent high temperature of the waste gases is the presence of soot and scale on the surface of the heating plate. The heat conductivity of both of these substances is very low, which fact emphasizes the importance of keeping the surfaces as free from such deposits as possible.

The heat imparted to the boiler by convection forms in most cases a large percentage of the total heat received. It is therefore very desirable, for the sake of better boiler construction and operation, that the factors which influence the rate of heat imparation by convection be more thoroughly known. Excepting a few experiments done abroad and bearing only indirectly on the steam boiler problem, nothing has been done toward determining these factors. The Steam Engineering Division of the United States Geological

* Abstract of a paper read before the Western Society of Engineers, Chicago.

Survey recently started the investigation of this problem, as an incidental feature in its regular work in testing the quality of coals for steaming purposes. These investigations consist of laboratory experiments made on small models of horizontal multitubular boilers. The laboratory methods and the small boilers were taken up because, first, it requires small outlay of money to conduct the experiments, and second, it is easier on a small laboratory apparatus to control all the conditions than would be the case with a large boiler and furnace; it is necessary in work of this kind to keep all the conditions constant.

In the experiments thus made small multitubular boilers were used because of their simple form, and heat was generated by a miniature electric furnace in order to avoid the deposit of soot on heating surfaces. As the result of a large number of careful tests, one of the most important observations made was that the heat absorbed by the boiler per second varies almost directly as the calculated initial velocity of air. With the same initial velocity of air, tests with higher temperatures show a higher rate of heat absorption; but as the initial temperature of the air rises, the rate of heat absorption does not increase in proportion to the temperature, and it is therefore probable that when very high temperature has been reached there is little or no gain in the heat absorbed by further rise in temperature. This fact indicates that the rate of absorption is influenced by another factor, which varies inversely as the temperature; this factor is the density of the gas.

It was also demonstrated from tests conducted that true boiler efficiency drops at first very rapidly when the difference of drafts increases; but when the latter reaches a certain value, which varies with size of tubes and degree of temperature, the efficiency remains nearly constant. The small gradual drop noted in the efficiency beyond the point where the latter remains nearly constant may be accounted for by rapidly increasing capacity.

It was also noticed that a given difference of drafts pulled practically the same amount of air through two boilers in which the tubes, of same diameter, in the one were nearly twice the length of those in the other. This would seem to indicate that most of the resistance is at the entrance of the flues and very little of it in the tubes themselves, so that increase in the length of the flues increases the total resistance but slightly. Nevertheless, adding to the length of flues does not, when carried beyond a certain limit, materially increase the true boiler efficiency, for it was shown in a test that by doubling the length of flues a gain of only 8 per cent in true efficiency was made. Further tests yielded results that would indicate the superior true boiler efficiency of the smaller diameter flues over those of the larger diameter.

The deductions drawn from these experiments, briefly summarized, indicate that:

a. After the velocity of gas parallel to the heating surface has reached a certain value the rate of heat absorption is almost proportional to the velocity.

b. The rate of heat absorption increases when the initial temperature rises; it also seems to vary directly with the density of the gas.

c. Increasing the diameter of flues decreases the efficiency of their absorbent power; increasing the length of flues beyond a certain limit increases their efficiency very little.

d. Most of the resistance to the passage of air through the flues is at the entrance into the tubes; the length of the flues increases the resistance but very little.

THE CATARACT DAM.

WATER CONSERVATION IN NEW SOUTH WALES.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

ONE of the largest and most important barrage construction schemes for the conservation of water that has yet been carried to completion in the southern hemisphere, is the construction of the Cataract dam, New South Wales, to meet the call for an increased pure water supply in the rapidly growing city of Sydney. The water supply for this capital is derived from the Nepean and Cataract rivers. The catchment area of 354 square miles, with the excellent rainfall characteristic of the coastal districts of New South Wales, is ample for the requirements of the city, for some years to come, despite its rapid growth; but the existing storage at Prospect, which is only 5,446,000,000 gallons by gravitation, is quite inadequate. Moreover, as the water from the rivers is conveyed to Prospect by a system of canals and tunnels having a daily capacity of 150,000,000 gallons, the storm flow of the rivers cannot be utilized to the best advantage.

Occasionally, moreover, severe periods of drought are experienced, and these have been especially frequent during the past few years, in which the severest was that of 1902. The demands upon the Prospect reservoir during such cycles has been so heavy as to cause considerable anxiety as to the supply. Though the citizens of Sydney have never been placed upon short rations, except occasionally in the matter of water for ornamental gardens, the resources had to be so carefully husbanded that it was decided to make greater avail of the larger quantities of water in rainy years, by constructing a masonry and concrete dam on the Cataract River, of sufficient dimensions to secure a storage capacity of 21,411,500,000 gallons. The undertaking was placed in the hands of the government Department of Public Works. Mr. L. A. B. Wade, M.Inst. C.E., the chief engineer for rivers, water supply, and drainage, was responsible for the design and carrying out of the structure, assisted by Mr. E. M. de Burgh, M.Inst.C.E., who has had principal charge of the work, Mr. J. Symonds being resident engineer.

The dam is 811 feet in length and towers for 157 feet above the level of the river bed, the foundations being carried down to a depth of 35 feet. The maximum total height of the masonry from base to top is 192 feet, and the maximum depth of water stored is 150 feet. The width of the dam at the base is 158 feet, tapering to 16.5 feet at the top. The lake thus impounded has a superficial area of approximately 2,400 acres.

The body of the dam is composed of cyclopean rubble masonry, consisting of blocks of sandstone weighing from 2 to 4½ tons, built to break joints both vertically and horizontally, and to have a maximum of bond. The stones are bedded in cement mortar, and the vertical joints are made with concrete. The proportion of blocks to concrete and mortar is approximately as 65 to 35. The upstream face consists of concrete blocks, measuring 5 feet by 2.5 feet, by 2 feet thick, set upon and jointed with special cement mortar, and backed by an average of 3 feet of basaltic concrete. The downstream face is of concrete 6 feet thick. The foundations are carried down to a depth of 35 feet below the bed of the river in solid sandstone rock. In the construction of the valve chambers at the base of the dam reinforced concrete is used.

The work of construction was commenced in October, 1902, under the system of day labor. The operations carried out included all preparatory work, such as road making, opening quarries, laying tramways for transportation of material, designing and establishing all plant, excavation for foundations, clearing, and so forth. Also a considerable quantity of the hearting and concrete work was built into the foundations. On the 10th of April, 1905, the construction of the dam was let to Messrs. Lane & Peters, the contract stipulating that the enterprise should be completed within two years. The actual time occupied in the work was four years and eleven months, and building during this period was carried on incessantly day and night.

In the construction of the dam three classes of concrete were used. That for the blocks on the upstream side, the lining of the offtake vertical shafts, and all surfaces exposed to the water was composed in the following proportions: Cement, 375 pounds; sand, 7.5 cubic feet; bluestone and shivers, 15 cubic feet, the latter being in the proportion of 3 parts of 2½-inch stone to 2 parts of ¾-inch shivers. The concrete for the outside of the 4-foot offtake pipes, the lower valve chamber, filling cutoff trenches and tunnels, as well as the hood of the valve chamber on the downstream side, was composed of cement, 375 pounds; sand, 10 cubic feet; bluestone and shivers, 20 cubic feet, the last named being in the same proportion as in the previous instance. For the downstream face in the hearting work where voids were large enough, filling shaft and between the backs of blocks and facing boards, the proportion of sand was increased to 11½ feet with 3-inch bluestone 20 cubic feet, to cement 375 pounds. Special cement mortar in the proportion of cement 375 pounds to 7½ cubic feet of sand was used for bedding the upstream blocks, while the hearting blocks were bedded in cement mortar composed of 375 pounds of cement to 12½ cubic feet of sand.

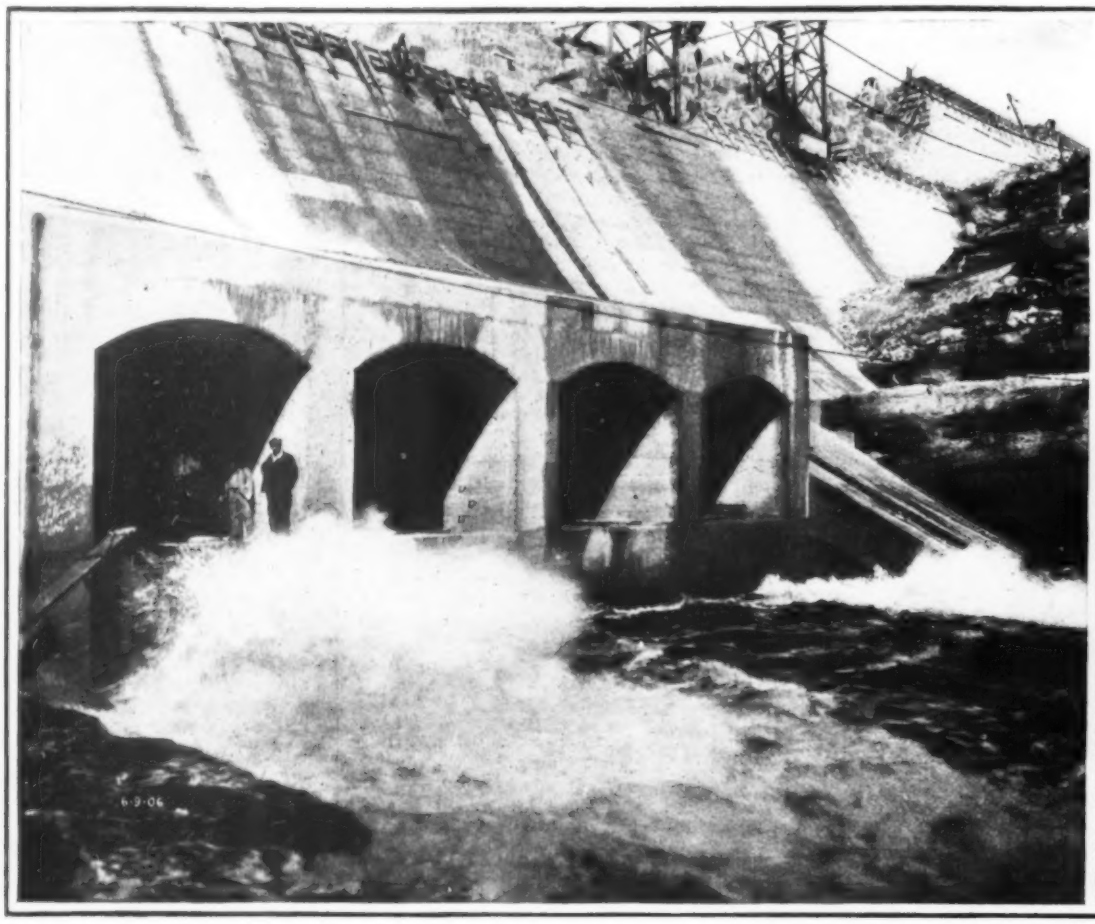
For the hearting of the dam between the upstream and downstream facework, no stones less than 2 feet in depth or having a less cubical capacity than 20 feet, when measured on the smallest dimensions, were used, the blocks being kept as large as practicable and of rough rectangular section. The stones were used green as they came from the quarry, and washed before setting into position, so as not to take up the mixture of the mortar and concrete with which they came into contact. The horizontal jointing was made as irregular as possible, the same practice being followed in regard to the jointing in plan. The conditions governing the work of construction were of a most stringent nature, in order to insure the most substantial type of structure. Tests both of the masonry blocks and the concrete and mortar were continuously made every day during the progress of the work. The sandstone used for the blocks has a weight of 140 pounds per cubic foot, with a crushing strength of 276.3 tons per square foot on a block of 12 inches cube. In regard to the compressive strength of the cement and mortar used, tests were taken at periods of thirty, sixty, and ninety days respectively, and were of an eminently satisfactory nature.

The sandstone used in the construction of the dam was obtained from two quarries, one at each end of the dam, from which the stones were transported to the desired position of cableways. A railroad was laid down to a point seven miles up the river, where hard basaltic stone was quarried for making the concrete, while sandstone suitable for crushing was secured within a distance of half a mile of the site, where the crushing and sand-washing plant was laid down.

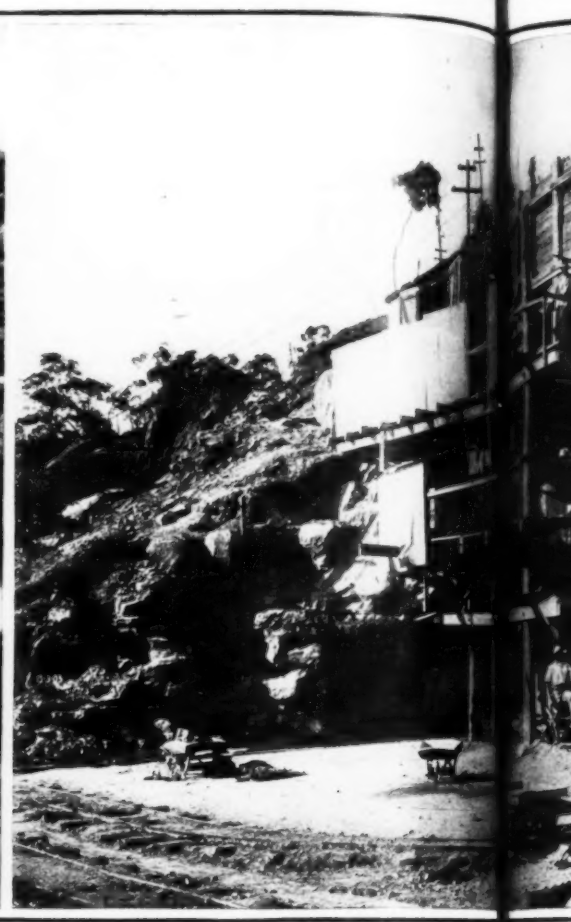
The foundations of the dam were found to be remarkably dry, very few springs being met with, and these when carried to the surface were found to give no pressure, and when the structure was completed were found to have no connection with or affected by the level of the impounded water. A very complete system of drains has been introduced in the body of the dam, for the purpose of carrying away any water which may penetrate the upstream face, and thus prevent any possibility of pressure in the wall. These drains are situated behind the concrete blocks forming the upstream face, and are collected into pipes which lead at intervals throughout the whole height of the dam from upstream to downstream face where they discharge. With a depth of 106 feet of water impounded, the flow from these drains is trivial; indeed, the structure proves to be remarkably dry. In constructing the concrete facing, parting joints were introduced at intervals, with a view to bringing contraction cracks to certain points. Such cracks have not yet developed, and it appears as if the large blocks of stone used and the bond obtained has distributed the contraction so evenly that no large cracks will result. Further, the upper portion of the wall where such cracks might be looked for was completed in the cold season, a fact that would tend to reduce contraction cracks.

A bywash to pass surplus flood with a weir 715 feet in length is provided. The top of the latter is about 150 feet above the river bed, the overflow joining the river about one-eighth of a mile below the dam. The top of the dam is 7 feet higher than the crest of the bywash weir. Two 48-inch pipes, with valves communicating with outlet wells and sluice valves in the upstream face of the work, form the permanent outlet; but two additional 48-inch pipes—making four in all—were provided to pass the river flow during construction. The valve house on the downstream side of the dam is roofed with ferro-concrete, which served as an excellent safeguard against damage by water topping the work during construction, and these valves were left open until the lowest portion of the wall reached a level approximately 80 feet above the river bed.

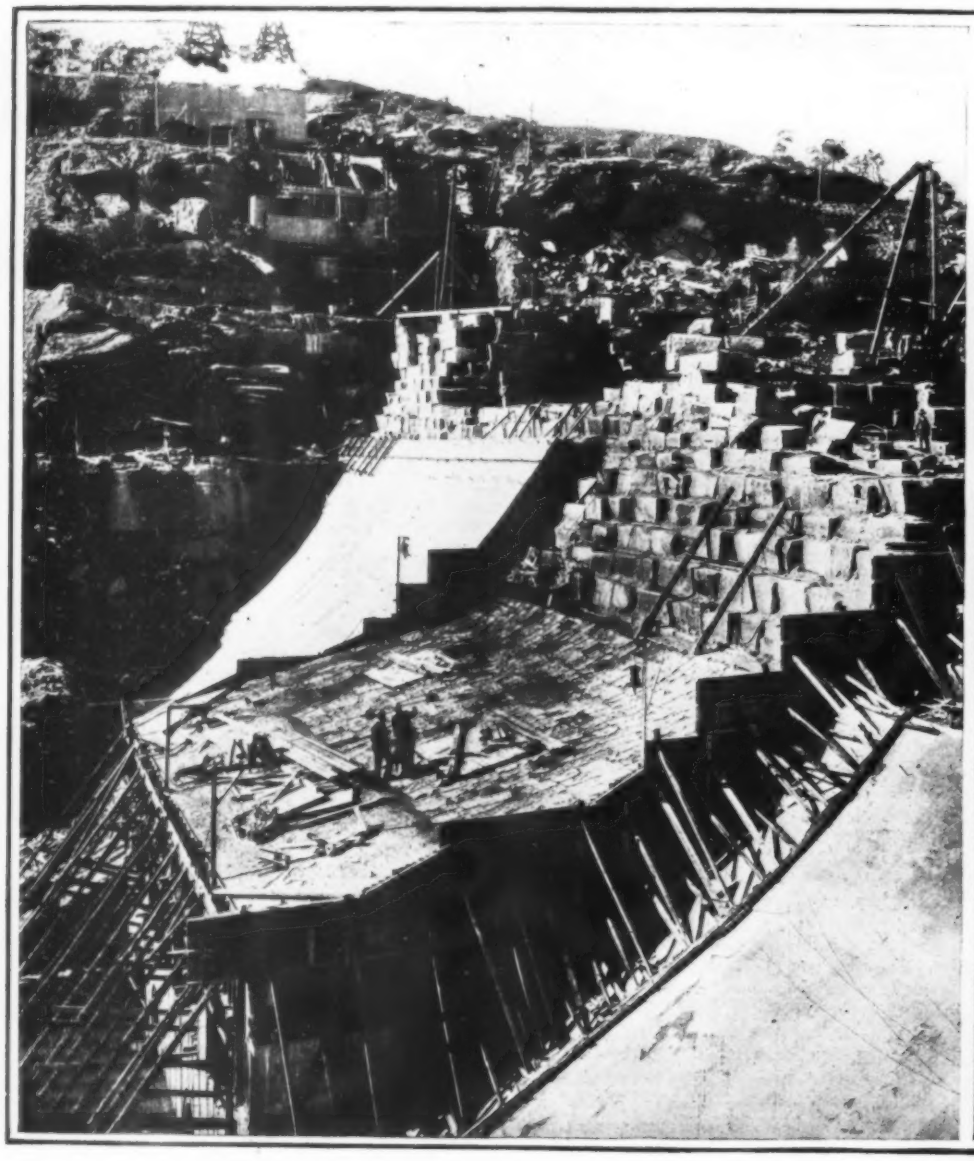
It was in connection with this provision that the remarkable coincidence which resulted in the discharge of an enormous volume of water over the dam occurred. An exceedingly dry period of fifteen months' duration prior to August 30, 1906, resulted in the depletion of the city supply, indeed, so low was the flow of the river during that period, that one 48-inch pipe was more than sufficient to carry it off. An arrangement was accordingly made with the contractors that the valves should be closed and water, if any, impounded on August 30. Two days before the last-named date, work was being concentrated upon the lowest portion of the wall, then 76 feet above the river bed, the gap being about 64 feet in width. August 29 was showery, and on the following day at 5 P. M. the valves were closed in accordance with the arrangement. At 6 o'clock the same day, after fifteen months' dry



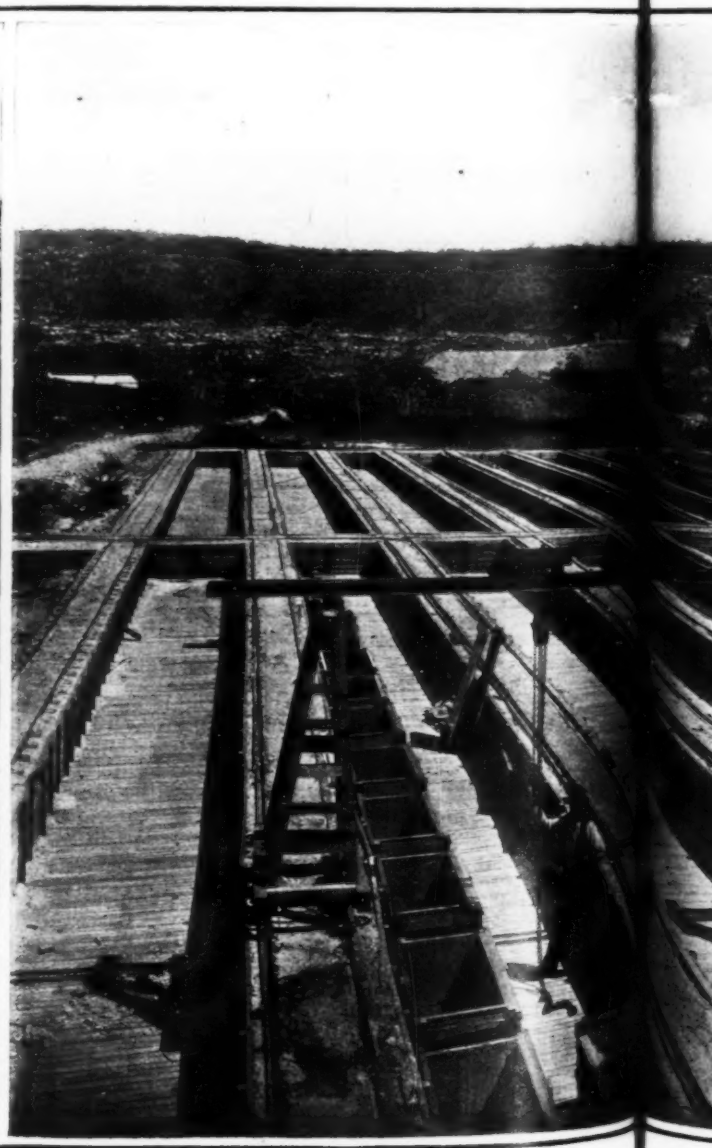
THE GATE OR VALVE HOUSE DURING CONSTRUCTION, SHOWING THE DISCHARGE THROUGH ONE 48-INCH PIPE.



CONCRETE MIXING HOU[illegible]R END OF



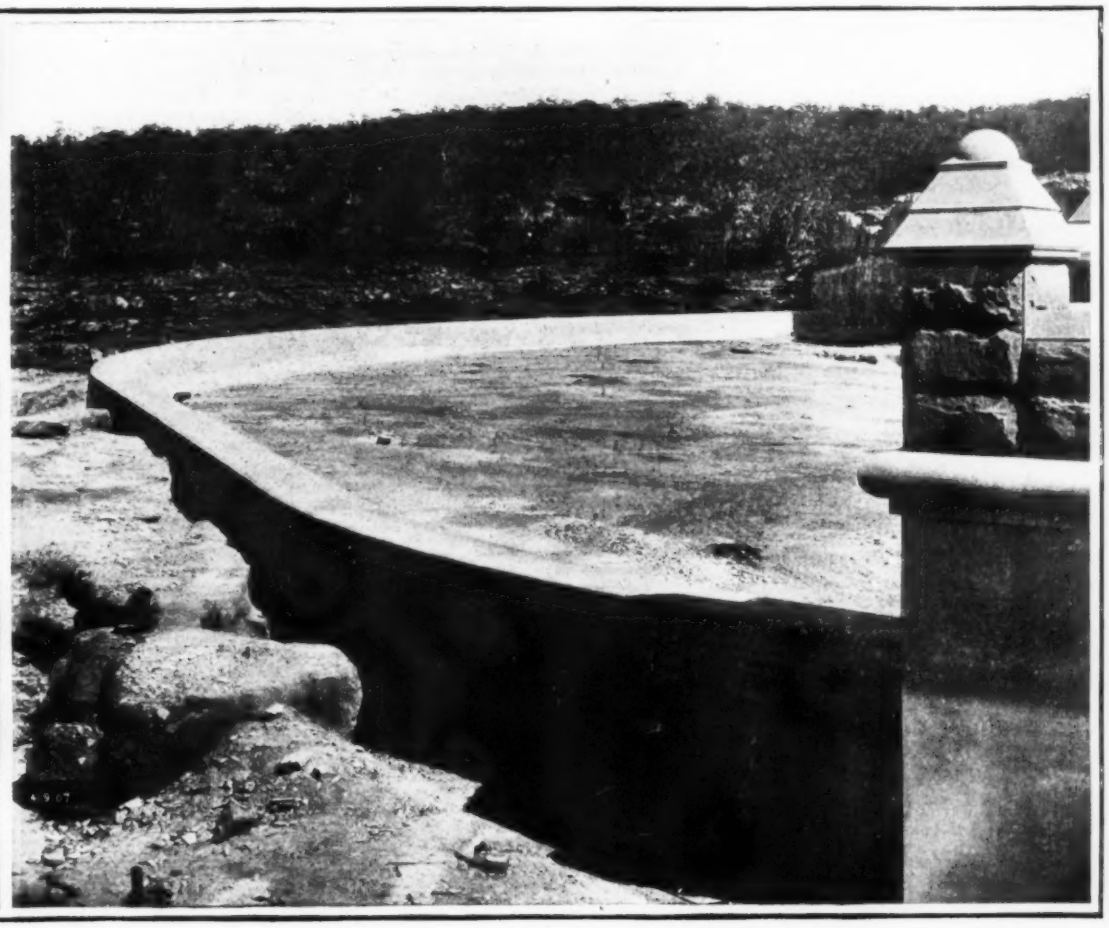
FACING AND CONSTRUCTING THE DOWNSTREAM SIDE OF THE DAM. THE ROOF OF THE GATE HOUSE IS BUILT OF REINFORCED CONCRETE.



YARD FOR MOLD[illegible]CRETE BL[illegible]

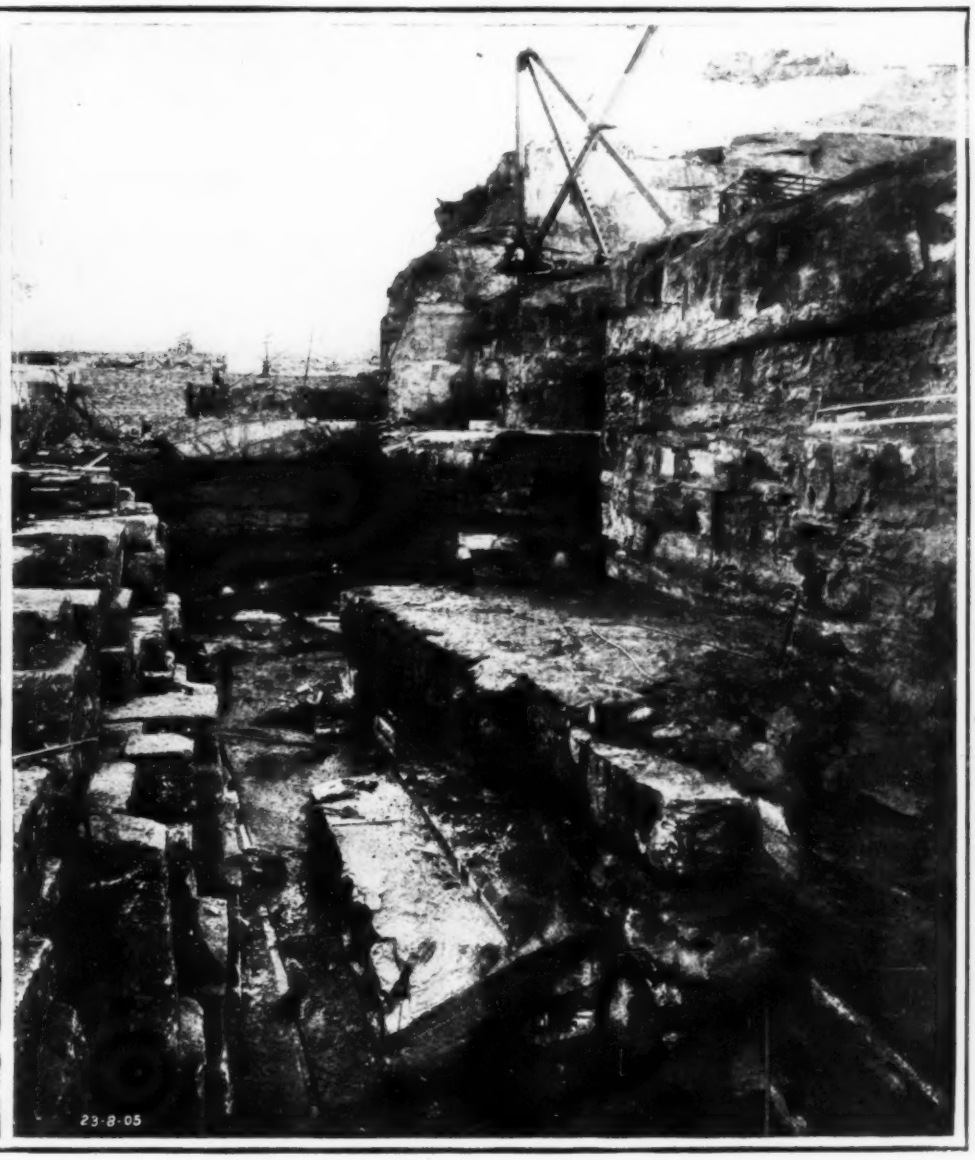
THE NEW DAM FOR INCREASING THE WA[illegible] SUPPLY

MIXING HOUSE AT END OF THE DAM.



BY-WASH WEIR FOR CARRYING AWAY THE SURPLUS WATER.

D FOR MOLDING CRETE BLOCKS.



SANDSTONE QUARRY AT ONE END OF THE DAM.

THE WATER SUPPLY OF SYDNEY, NEW SOUTH WALES.

weather, heavy rain—amounting to 10 inches—fell in the catchment area, and by 6 A. M. on the following day, August 31, the water was flowing over the dam to a depth of 16 feet through the gap, the lake above the dam holding at the time approximately 2,000,000,000 gallons of water. The engineers opened one of the 48-inch valves to reduce the surcharge, but it was not considered advisable to open the other three valves, on account of the vibration likely to result from the high velocity, as the fixing of the valves was not completed. Rain ceased on August 31, and on September 3 the discharge from the open valve and over the wall had reduced the level of the lake to the level of the top of the wall—viz., 76 feet—when the valve was partially closed and work resumed. No damage was done to the structure, though one or two blocks of sandstone not yet set were carried from the top of the wall.

By the completion of this undertaking, a sufficient supply of water under all and varying conditions is assured to the city of Sydney for many years to come, and any apprehensions concerning a water famine even in the years of severest droughts are now satisfactorily overcome. The total cost of the enterprise was approximately $1,650,000.

THE BASIS FOR A NEW GEOLOGY.—III.*

RAISED BEACHES AND THEIR CAUSE.

BY H. W. PEARSON.

Continued from Supplement No. 1682, page 204.

IN following up the astronomical hypothesis as to the cause of the Biblical and other floods, as presented in our preceding paper, with the object of discovering the existing relations between actual geologic formations and the actual raised beaches, we must first note as follows:

The eccentricity of the earth's orbit is at present expressed by the decimal 0.0168. In past ages, however, the eccentricity has been so much greater that the difference between aphelion and perihelion distances—to-day but three million miles—has been in excess of fourteen million miles. That is to say, that cause which under our guiding hypothesis is responsible for the recent submergence of the central United States to a depth of nearly 1,000 feet, has during the last 850,000 years had value four and one-half times that of the present. ("Climate and Time," Plate IV., p. 312.) The increased activities to be expected from these greater values should lead to the inference that as we follow these alternating submergences backward in time, we will find the greater elevations of the older and more obscure shore line testifying to a considerable increase in depth of the overlying waters, in correspondence with the great increase in eccentricity.

These higher, fainter, and more ancient traces of elevated seas have, as matter of fact, been observed in all northern countries.

Ritter, Le Conte, Lawson, and many others have shown them on the Pacific coast to elevations of 1,200, 1,475, 1,600, 1,700, and 2,100 feet. The publications of the Geological Surveys of the United States and Canada have made them known in Alaska at all elevations to upward of 3,000 feet. Watson, Packard, Bell, and others have recorded beaches of 1,200, 1,400, 1,500, 1,857, and 2,000 feet and upward on the coasts of Labrador. Spencer, Taylor, Coleman, Upham, Dowling, Tyrell, and Chalmers have noted them in various parts of Ontario, Manitoba, and the Northwest Territories, to altitudes ranging from 1,000 to 2,100 and 2,200 feet. Hitchcock registers terraces in the White Mountains to 2,449 feet, and in Connecticut to altitudes of 2,022 feet. Other observers of high-level terraces in the eastern United States are too numerous for mention, although Fairchild and Spencer in New York, Winchell and Upham in Minnesota, Spencer in Mexico, Stevenson and White in Pennsylvania, have all made great contributions in that direction. Mr. F. F. Stevenson in particular has given us beach elevations in southwestern Pennsylvania of 1,445, 1,475, 1,520, 1,690, 1,880, 2,123, 2,288, and 2,323 feet. (Report K, K. K. Second Geolog. Survey of Pa.)

The same condition is found in Ireland, England, Scotland, Norway, Sweden, France, and the entire European coasts, a great number of observers having recorded elevations of 1,200, 1,400, 1,600, 1,800, and 2,000 feet, and in the case of J. R. Daykins, in Norway, to altitudes of 2,300 and even 3,100 feet. (Geolog. Mag., vol. iv., pp. 72 to 75.)

It is now perfectly evident, from the above fragmentary exhibit, that the greater submergences demanded by the greater eccentricities of the geologic past have had actual existence; and if we would study the connection between these deeper waters and their corresponding deposits, it is first necessary to map one of these more elevated inundations.

In "Climate and Time" (page 312) is illustrated, by diagram, the eccentricity of the earth's orbit for 3,000,000 years preceding 1800 A. D. Examination of this curve shows that the lesser differential distance of 3,000,000 miles, or the greater of 14,000,000 miles, previously mentioned, have been of very rare occurrence. If repetition of submergence has really been caused by these disturbing functions, the greater number of these inundations must have had intermediate depths proportional to the average eccentricity. This seems to have been about 0.0317, if we can take the average of the ordinates obtained by Dr. Croll from Leverrier's formula. This value would correspond perhaps to a difference in aphelion and perihelion distances of say 5,800,000 miles.

We now map the eastern United States at the period of one of these older submergences of intermediate depth above mentioned, and for the purpose of our argument will choose a polar depth of 2,000 feet instead of the submergence of 1,467 feet as exhibited in Fig. 6.

The result of this mapping is shown in Fig. 7; the waters of that particular inundation having a depth of 845 feet at Key West, 1,150 feet at Cape Hatteras, 1,312 feet at New York city and 1,380 feet in southern Nova Scotia.

If we now give attention to the form and position of the coast lines, when the North is submerged as above indicated, we are at once struck with astonishment at the precision with which the outer limits of this inundation for thousands of miles in the United States are in agreement with the outer limits of the Coal Areas. This extraordinary coincidence in boundary lines, combined with the similar coincidence of the lignites with the coast lines in Fig. 6, leads naturally to the strong suspicion that the coal beds must in some manner be related to or connected with these submergences.

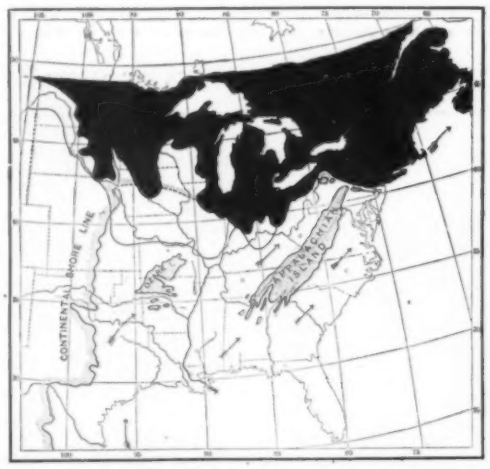


Fig. 7.—The Eastern United States at the Time of a Polar Submergence of 2,000 Feet.

Illustrating the correspondence between the coast line of that period and the limits of the carboniferous formations.

We have long known that the northern rock formations could only be explained by assuming that the sea had often in the past covered this continent, but it seems that heretofore we have not allowed ourselves even to imagine that a similar origin could be advocated for the coals. Now, however, we learn that such derivation may be quite probable. We know that vegetation, for long ages past, has existed upon the northern lowlands. We have most positive evidence that during past geologic periods the sea has again and again passed deeply over the North. We have perfect license therefore to inquire as to what disposition the Tertiary, Triassic, Cretaceous, Carboniferous, Silurian, or other seas have made of the enormous masses of forest debris which they must have devoured in their advance over the hemisphere. In other words, our research on the raised beaches seems now to be compelling us to a rediscussion of the *driftwood origin of coal.*

This drift idea of coal accumulation was strongly advocated by the geologists of a century since, but at a later period was generally abandoned in favor of the growth *in situ* hypothesis.

In more recent years, however, the discovery of facts impossible to explain under this latter theory has again shaken our faith, and many of our geologists have returned either to the old doctrine of drift origin or have admitted that as yet the problem of coal accumulation remains entirely unsolved.

Prof. Joseph Le Conte, who did much to cause the rejection of the drift and the acceptance of the growth in place theory, through his analysis of the question in the Smithsonian Report for 1857, has stated his more recent conclusions in the following language: "There has been much dispute upon this subject (of coal accumulation) and it is still obscure." Again: "It may be difficult . . . to form a clear picture of the precise manner of accumulation, and therefore there is still *a large field for the play of fancy.*" ("Compend. of Geology," pages 295 to 296.)

Perhaps the strongest recent argument in favor of our return to the principle of drift origin is that of Prof. James Geikie in his "Structural and Field Geology." Among other statements, he says: "Some coals cannot possibly have resulted from the growth of plants *in situ.*" (P. 329.) As to other beds he says: "Such coals were accumulated in water; . . . in short, they are sedimentary formations." (P. 330.)

From this preliminary discussion it appears clearly that the field is still open, no hypothesis yet offered as to the manner of coal accumulation satisfies the many perplexing conditions of the problem, and we will therefore again take up the thread of our own research.

At the very outset we realize that if we are to learn in what manner, and at what point, the sea is to unburden itself of the mass of vegetation it has acquired in its passage over the land, we must study the direction of flow, and the geographical position of the oceanic currents of a particular submergence, and especially must we study the relation which the new directions of these displaced and elevated currents may bear to the rearranged coast lines. In other words, we must know as to the frontal aspect which these barriers may have to the currents at a period of high sea level, as it is along these barriers, or in lagoons and catch basins which may be opposed to the direction of flow, where we must expect to find the accumulated vegetation.

Heretofore no method seems to have been recognized by which we can determine the direction of flow in the currents which washed the shore lines of a submerged North, except by actual examination of the deposits resulting from the elevated waters, but this is not often practicable. It is desirable therefore to find the law controlling this matter of direction, if such exists, and it is believed that the following extract from a recent paper by this writer may contain that of which we are in search:

"Under our hypothesis, a vast accumulation of water now submerges the South. These waters will soon be compelled to begin their journey to the North. Let us assume that this transfer has commenced, and let us attempt to discover the route or path these waters must adopt.

"The earth's surface at the equator has a motion to the east, due to the daily rotation, of say 1,040 miles per hour; in latitude 70 degrees south the velocity is but 350 miles per hour. Let us now take a unit of this northward-moving water at latitude 70 degrees in the South Atlantic, where the eastward motion of the earth's surface is 350 miles per hour, and move it instantaneously to the equator, where the surface has a velocity of 1,040 miles per hour. We then observe that this unit immediately starts an apparent movement toward the coast of South America at the rate of nearly 700 miles per hour. This transfer of water will certainly require a period of months, instead of being instantaneous, as supposed herein; but the fact remains that if water is passing northward from the given position in the South Atlantic, it can never reach the equator until it has undergone an acceleration in its eastward motion of 700 miles per hour. This acceleration may be obtained by any one of three methods. The waters may, in their northward journey, press against other currents of water: they may be crowded to the east by the irregularities of

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

the ocean bottom; but their final acceleration must certainly be acquired from their impingement on the entire eastern shore line of South America, from which there results the necessity of assuming that the waters adjacent to this coast will be heaped or piled up *for above the normal level of the sea.* This heaping of the waters on these shores, combined with the fact that the easterly apex of the continent is considerably south of the equator, compels the diversion of the northward-moving current into the bight of the Gulf of Mexico, where these waters receive the final acceleration due to the earth's rotation. We see, also, that in this gulf the surface of the ocean must necessarily be far above the normal sea level, and, consequently, the escape of these waters through the straits of Florida at a rate of four miles per hour needs no further explanation. This velocity of flow is due to the hydraulic head in the Gulf of Mexico, and the convexity of surface in the escaping current is a physical necessity from the attendant circumstances.

"Waters flowing from the gulf and still moving northward are now always traveling faster to the east than the surface of the earth over which they are moving. They are consequently compelled to a direction of northeast, and having left the Florida shores with a velocity of about 1,000 miles per hour, they must suffer retardation of something like 600 miles per hour before reaching the coast of Scandinavia, where the final retardation must be accomplished by the crowding of these waters against the coast lines of Norway and the British Islands. Here also the sea level must necessarily be deformed and raised far above the normal.

"It follows from this discussion that if water is passing northward of the Atlantic, it can by no possibility follow other route than that of the present Gulf Stream. It follows also that with any change in shore lines, due to the elevated seas we have under consideration, the patns and positions of the ocean currents of the period, with their direction of flow, can still be determined through application of the same analysis." (Journal of the Ass. of Eng. Soc., vol. xxxii., pp. 9, 10.)

As a result of this analysis as to the effect the earth's rotation may have upon ocean currents, we are now enabled to place upon Fig. 7 certain arrows which represent both the approximate location and the direction of flow of the Gulf Stream at the given epoch. With this data before us, it seems that we are now prepared to forecast with considerable accuracy where the devastated forests of a northern submergence will become permanently stranded in the shallows, or become embayed in the lagoons, recesses, or catch basins of our elevated coast lines. For example, inspection of Fig. 7 shows a great recess or bay in Ohio, Pennsylvania, and West Virginia, between the ice cap on the west and the Appalachians on the east, with a narrow outlet or channel near where is now the city of Williamsport, Pa. Through this channel, under influence of the hydraulic head in the interior basin, as previously demonstrated, there must have been a strong outflowing current similar to the present flow between Florida and Cuba. Into this bay, therefore, impelled by the Gulf Stream itself, must have been swept a great portion of the oceanic flotsam, and when so accumulated there the material must have remained until it sank through saturation, as egress to the south, against the current, or to the east through so narrow a channel, were both impossible.

The subsequent history of this ponded vegetation can be inferred from our knowledge of similar drift accumulations of the present day. Le Conte has mentioned the great raft of the Atchafalaya, which was 10 miles long and bore trees 60 feet high. ("Elements," p. 143.)

Reclus in "The Earth" describes a raft in the Red River which was 124 miles long in 1833. From these authorities and other sources we learn that these rafts are of greater age than would be supposed possible. Trees estimated at 200 years old have been cut from their lower ends, and the entire surface of the driftwood, except the more recent additions at the upper extremity, is covered with a rank growth of ferns. Now, then, when this material sinks, these ferns will descend to the bottom, not in the form of pulp, as has been heretofore assumed by the opponents of the drift hypothesis, but each in perfect condition, and their fossil remains will always be found on the "top of the seam."

Furthermore, these fossils will in almost every case have inclination in the direction of the prevailing current, as shown by the arrows. This writer, in several instances in Pennsylvania, has confirmed this theoretical direction of inclination by actual observation, but he has yet to learn of similar observations by others.

The drift hypothesis also affords explanation for many other problems, which have long perplexed us. For instance: If we make the most probable assumption that the older drift material is that which will first reach the point of saturation, we observe that the vegetation nearest the shore line, at the head of the basin, will be the earliest to seek the bottom. The disappearance of the material will therefore allow the water's surface to be again and again replenished through the advance of new debris, and consequently a coal bed of any thickness whatever, may be obtained by the successive sinkings of rafts of moderate thickness. The several sections in the resulting deposit being separated by a "bone" parting due to sedimentation of thickness proportional to the time interval between the different sinkings.

Near the shore line, it is certain also that the deposits from flooded streams will often thicken up these bone partings until we will have what has been called a "split seam"; this name having been applied by miners to those cases where a slate parting of one or two inches thickness has in a short distance increased to several feet.

These split seams, and the minute slate partings above mentioned, altogether too thin to support the vegetation necessary to supply the overlying coals, have heretofore found no explanation under the growth *in situ* hypothesis.

Again: It is readily seen that these vegetable masses, when deposited at the bottom, will adjust themselves to every irregularity of that surface. Every ridge, every valley, every fold of the diversified and rolling topography of the submerged area, will be reproduced in facsimile in the coal beds. In the case of vertical precipices, like the Palisades of the Hudson, or the acclivity on the south bank of the Monongahela at Pittsburg, we will find, when deposits from overlying waters have superimposed later formations upon the present surfaces, a rock stratum extending horizontally a considerable distance, then breaking off abruptly, with great vertical displacement, and the reappearance of the same horizontal stratum, identical in thickness and material, 300 feet vertically below its former position, and all this without motion in the earth's crust.

Up to the present time the geological doctrines of to-day have invariably ascribed all "folds" and "faults" in rock strata to the crustal strains and motions produced by a contracting and cooling earth. It is clear now, however, that our attitude in this regard can no longer be maintained. It is true that much

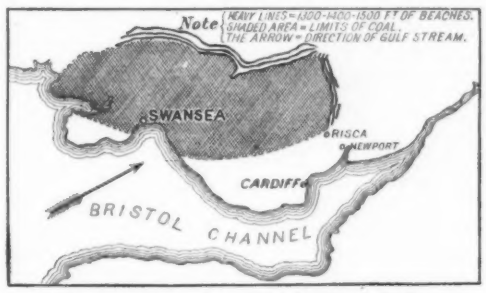


Fig. 8.—The Coal Area of Southern Wales.

flexure and slipping of strata and many minor contortions will arise from the fact that when the vegetation was deposited, it had thickness some sixteen fold greater than the eventual coal bed.

All sediments deposited, therefore, over a mass of material say 100 feet in thickness, must suffer a slow vertical descent of 94 feet, continued for the thousands of years necessary to transform this vegetation into a coal bed 6 feet thick.

This compulsory motion has undoubtedly generated much of the heat necessary for the transformation of vegetation into coal, and of sediments into slates, and on irregular and inclined floors, where the direction of motion may be often opposed, has caused many minor contortions, foldings, and overturns. But these phenomena can no longer be attributed to motion of the crust proper. They are confined strictly to the surface. There seems no necessity, therefore, for giving a contracting earth either place or occasion in these matters.

Having now shown that each and every peculiarity of the coal beds, their wide extent, their uniformity in thickness, their overlying ferns, the alternation of marine and fresh-water fossils, the conditions of structure and lamination, and all other phenomena of interstratification, with their associated sedimentary deposits, can better be satisfied under the theory of drift origin than through any other hypothesis yet offered, we will resume the subject of the geographical distribution or actual location of the coals.

In this study we shall discover facts, previously unknown to us, so important, so convincing, so impossible of refutation, that it is difficult to see how we can escape the conclusion that hereafter the drift origin of coals must take precedence of all other systems of accumulation.

We have already seen how the vegetable debris from the overthrown forests at the South would be carried into the great bay or recess which once extended over portions of the States of Ohio, Pennsylvania, West Virginia, and Kentucky; but if we compare the limits of this submerged area with the limits of coal areas in these same States, as shown by the carboniferous maps, we at once observe a practical identity, that is to say, *the actual coals are in position exactly as they would be if they had been derived from the floating vegetation of a submerged North.*

Furthermore, Fig. 7, it will be seen, reproduces almost precisely the bounding limits of the carboniferous formations in the eastern United States. If detailed study is now applied to these and other areas, it will be discovered that a correspondence precisely similar to the above, between the limits of the beaches and the limits of the coals, exists throughout the entire carboniferous of eastern America. In other words, to construct maps of the coal areas of Mexico, Texas, Kansas, Missouri, Arkansas, Nebraska, Illinois, Iowa, Indiana, Alabama, Tennessee, and Nova Scotia, we have merely to reproduce the shore lines of those States at a particular altitude, and indicate upon these barriers the drift accumulation we have been discussing. The result will be a complete delineation of the coal areas of the several States and countries above mentioned. In Ohio, Indiana, Iowa, Nova Scotia, and perhaps elsewhere, attention of course must be given to the limits of the glaciers.

In Fig. 7 we elected to map a submergence of 2,000 feet at the pole, or say 1,300 feet in the central United States, while from the beaches we learn that the waters in this region have had depths ranging from say 950 to 2,300 feet. It is, however, a matter of indifference, to some extent, as to the particular depth to be chosen in this mapping, provided search is made for coal beds corresponding to the beach altitudes. For instance, if we map out the last submergence, as in Fig. 6, we will find no corresponding coal deposit in Pennsylvania, for the reason that floating vegetation at that time had no access to these northern regions. We will find our material instead below the Boulevard Beach, far to the south, in the States of Alabama and Arkansas, and owing to its recent deposition, it retains the form of lignite.

If a depth of 2,000 feet or 2,300 feet is chosen, we would then find the channel in central Pennsylvania so wide that no floating debris except small isolated patches along the coast line, like the Blossburg or Broad Top coals, would be intercepted in that State, the main body of vegetation passing freely into the North Atlantic. The last-named high-level deposits may therefore be considered as productive fragments of the otherwise barren measures.

In Fig. 8 the heavy black lines represent the 1,200, 1,400, and 1,500-foot beaches of southern Wales. The shaded area shows not only the compulsory location of drift material when impelled by a current acting in the direction of the arrow, but exhibits as well the actual situation of the greatest coal deposit of Great Britain.

Data as to elevations in this map have been obtained from one-inch ordnance sheets Nos. 231, 232, and 250.

At a point about one mile north of Risca the descent from an elevation of 1,374 feet is most abrupt to a level of about 700 feet. This point, therefore, being the last high-level barrier in southern Wales, must necessarily be the southern termination of the coals in that region.

In manner similar the coal areas of Belgium, Germany, France, and all other countries for which topography is accessible, can be shown as located invariably where the 1,000 feet to 2,000 feet coast lines of a submerged North maintained such aspect to the current as would compel the stranding or embayment of forest debris. From this demonstration of correspondence between beach and coal limits, repeated one hundred times over through the geological ages, we now request permission to use the boundaries of the coal in themselves as *original beaches.* If this is admitted, the diagram of concentric curves in Fig. 4, upon which our argument to some extent depends, is confirmed and reproduced one hundred times over by the coal beds.

It has now been established that the great raised beaches, when properly questioned, are capable of yielding a system of geology in complete conformity, not only with all requirements and conditions of the internal structure of coals, but also with their geological distribution.

It explains as well the limitations in extent of all the overlying carboniferous slates, sandstones, and shales, and introduces chronology into the entire series of formations.

It might be supposed from all this that a system which thus explained so many matters previously obscure, which solved so many perplexing problems, and which fitted so precisely to all known facts as to coal distribution, would be readily acceptable, but this is not the case. A little reflection will show that the scheme we have advanced *presupposes a rigid and inflexible earth.* The curves of the beaches and the curves of the coal beds alike unite in denying movement in the crust since the period of the carboniferous. Our present doctrines, on the contrary, assume that all things on the earth's surface are in perpetual motion. Here, then, the old comes in direct conflict with the new, and acceptance of the results so logically derived from the raised beaches must consequently be refused, unless it can be made to appear that our present doctrines are not well grounded.

In this suggestion, that error may be found in some of our fundamental beliefs, we are bringing forward a question too wide and too important for immediate discussion. We can only say here that it has long been known that some of our doctrines are in direct opposition to the requirements of physics and mathematics. Heretofore geologists have maintained that there is no evidence in the stratified rocks to support the mathematicians in their rejection of the doctrine of contraction, or in their affirmation of a rigid crust. Now, however, so much support is afforded the geometers by the geologic facts obtained from the beaches, that the whole subject of geologic belief should be reconsidered. Especially is this derivable in view of the fact that our present fundamentals were originally *not based on knowledge*, but on inference and on the balance of probability only.

(To be continued.)

THE FORTRESS OF THE MOLE.

BY W. P. PYCRAFT.

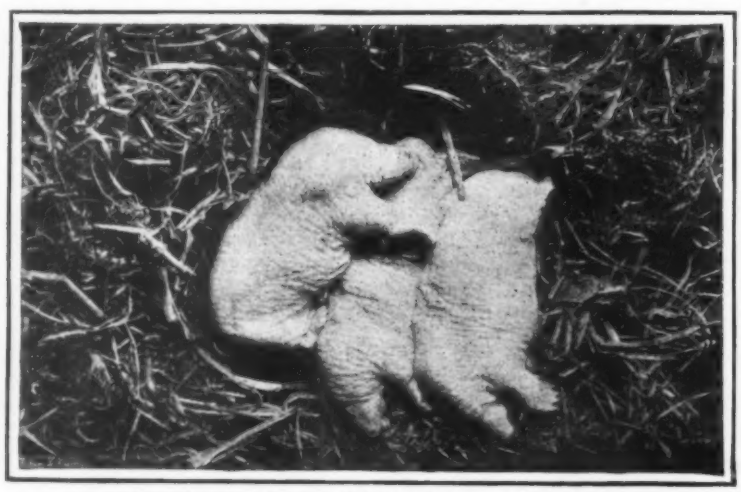
UNTIL quite recently the "fortress" of the mole was universally regarded as one of the wonders of Nature. But, alas! this, like so many wonders, has now been shorn of its gilded glory. For generations the mole and the bat, as fancy dictated, were placed before us as the standard of blindness, but this we have long since abandoned. Nevertheless, it must be admitted that truth is better than fiction; and, by way of compensation for this admission, we not seldom find that it is stranger, more unbelievable, more incomprehensible! If, then, the stereotyped picture of the mole's fortress that has so long adorned our textbooks and works on popular natural history must go, what is to replace it? Happily, we can reply, something only a little, if any, less marvelous. In short, we find that, instead of a wondrous work of engineering, perfectly uniform in type and plan, we have a scarcely less wonderful piece of underground tunneling which varies not so much according to the vagaries of the architect as according to the conditions of the site, and herein these lowly animals show a discretion that we had not previously suspected.

For the real facts of this matter we are indebted to Mr. L. E. Adams, who, about five years ago, took the trouble to patiently study the building plans of a number of these subterranean dwellings. He showed conclusively that more or less complicated galleries are purely incidental, and have no reference to premeditated escape in times of danger. There seems to be good reason to believe that the breeding fortress is built and inhabited by the female alone, the male building a dwelling place for himself of a somewhat more [illegible] character; but whether, before the breeding season, the female occupies the apartments of the male is not yet known. The breeding fortress of the female, placed sometimes in a hedge-bank, but apparently quite as often in the middle of a field, is begun in the autumn or early winter, and this remains the home until the young leave in the June or July following. About one foot high and often as much as three feet in diameter, this curious dwelling place is found to be made up of an outer fortress inclosing a hollow chamber, and beneath this an inner chamber in which the nest is placed. As a rule, some seven or eight tunnels, more or less equidistant, traverse the dome, but do not appear to lead into the chamber or loft above the nest, which seems to serve the purpose of regulating the temperature of the nest below. The tunnels for the most part are, according to Mr. Adams, excavated for the purpose of getting rid of the soil removed during the construction of the nest; two, however, have a special purpose, one being used as a "bolt" hole, and the other, which is driven vertically downward for as much as one yard in length, being used, according to some, as a drainage shaft, or to others as a storehouse, down which worms, paralyzed to prevent their crawling away, are dropped for future use. On this point, however, further observations are necessary. The tunnels leading from the nest are often, indeed generally, of a corkscrew shape and often end in a *cul de sac*. Besides these tunnels, however, there is commonly a second series, unconnected with the central nursery, but traversing the fortress from external runs, through which earth has been carried to heap over the nest. The nest cavity, which is about the size of a cottage loaf and worn smooth by friction, contains a ball of grass and leaves, or a mixture of both, and here from two to seven young are produced, which leave the nursery in about five weeks. When first born, they are absolutely naked, and have the eyes sealed up, as may be seen in the illustration, while the skin is pink in color, and sometimes, at any rate, shows blood-red patches. A further point of no little interest is the fact that the limbs are relatively longer than in the adult. It would be well if, in this connection, observations were made with a view to discovering whether the eyes are also larger, even though concealed by the skin. One would expect to find this to be the case, and also that some signs at least of an external ear or "pinna" would be traceable.

A careful study of the illustrations will show that the growth of the fur takes rather a long time, since even at a fortnight old the young mole is only covered with the shortest of fur, which at this time has all the appearance of velvet. No trace of the eyes can yet be made out, but in both the earlier and the later stages the ear can be plainly discerned. In the young at two days old this appears as a minute pit in the middle of a slight swelling just where the arm joins the head, while at a fortnight old it can be more clearly made out. At this stage, too, it will be noted, the snout is relatively much longer.

The mole is a very resourceful animal, contriving to hold its own even under what would appear to be uncongenial surroundings, inasmuch as it will construct its fortress in wet and boggy ground as well as in drier situations. In the latter the nest may be six inches or more underground, while in the former it is placed on a level with the surface, the soil being heaped up above it to afford the necessary privacy. Only in rocky ground does it appear unable to dwell.—Country Life.

A FORTNIGHT LATER.



YOUNG MOLES IN NEST THREE DAYS OLD.

ROMANCE OF MALLEABLE IRON.

WHAT is known in America as malleable iron is used to a great extent on vehicles of all kinds because it is stronger than cast iron and less expensive than wrought iron or steel castings. What we call wrought iron is called malleable iron in Europe, which has led to considerable misapprehension about the real nature of our malleable iron.

Many people who are in a position to order malleable iron when they consider it suitable have very vague impressions concerning the nature or qualities of this material. They believe malleable iron to be ordinary cast iron that has been subjected to an annealing process that increases its strength and gives it toughness. Seventy years ago there lived in Newark, N. J., Seth Boyden, a blacksmith by trade, who became a sort of Admirable Crichton in everything relating to the mechanic arts. This man, besides possessing great inventive and mechanical ability, was gifted with extraordinary acuteness of observation and faculty that ought to receive more encouragement than it does from the educational world.

When he was yet a lad Boyden noticed that a grate bar which had been removed from a furnace had apparently changed its quality on the part exposed to the fire. He broke off the part that seemed to have undergone the metamorphosis and found that it could be drawn on the anvil. By some mysterious process the cast-iron bar had become malleable.

Boyden proceeded to search for the secret cause of the change. All his spare time was devoted to the search, and after long and tedious experimenting he found out that when cast iron of a certain quality was kept at a high temperature surrounded by oxide of iron, the cast iron lost its high percentage of carbon and became soft, tough, and malleable. The discovery was so important that Boyden had no difficulty in finding help to raise the means for making malleable iron as a business.

The castings are made in dry or green sand molds that do not differ materially from ordinary cast-iron molding. The iron is poured very hot, and the product is a shiny gray, highly brittle casting, these characteristics being principally due to the selection of the pig iron. The castings are then put into square boxes where they are imbedded in oxide of iron mostly in the form of iron scale and rust. These boxes are then closed in a heating furnace, where they are kept at a very high temperature for about eight days, after which the furnace is permitted to cool gradually. As soon as the furnace is cool enough, the castings are ready for cleaning. The metal thus treated possesses the desirable elements of toughness and durability, and has now a multitude of uses for which it is fitted as no other metal is.—Railway and Locomotive Engineering.

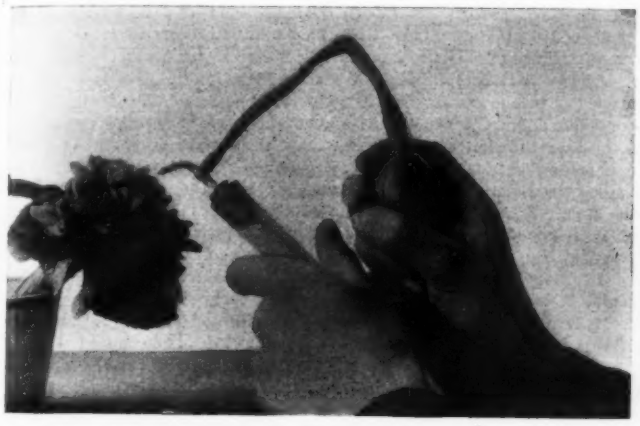
THE FLOWER DOCTOR.*

A STRANGE KIND OF SURGERY.

BY S. LEONARD BASTIN.

THE discovery of the commercial value of flowers is one of the most remarkable developments of our times. Even the advanced gardeners of a century ago had not the faintest idea that one day huge industries would spring into being, having for their sole object the culture and marketing of blossoms. As one would expect, the appearance of this floral enterprise has led to the creation of many positions for those who specialize, which otherwise would never have seen the light of day. Quite the most remarkable of these novel vocations is that of the flower doctor—a man, or not infrequently a woman, who gives his or her whole time to the handling of blossoms with a view to making good any imperfections which they may possess.

Nature is quite perfect in her ways as a general rule, the flower doctor readily admits, but even she will sometimes make mistakes, and quite often will be all the better for a few touches from his skillful hand. Of course the very first principle of this curious art is concealment; the work must be done so well that no one can discern that it has been done at all. Flower doctoring is very much more widely practised than might be supposed, and it speaks well for the skill of the operator that so few people are even aware of the existence of his strange profession. In the present article it will be the endeavor of the writer to give the reader a little peep behind the scenes in a modern flower-growing establishment.

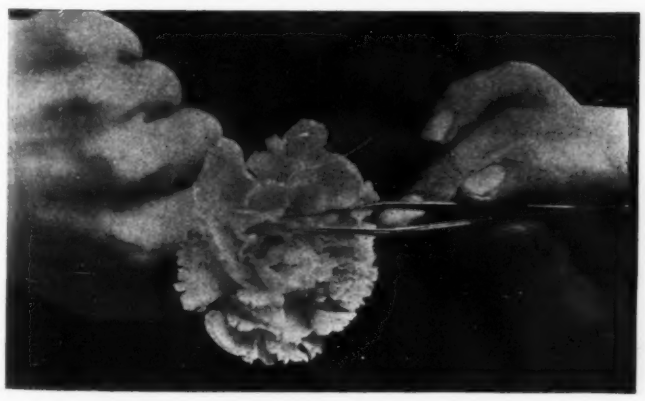


SPRAYING ODORLESS VIOLETS WITH ARTIFICIAL SCENT.

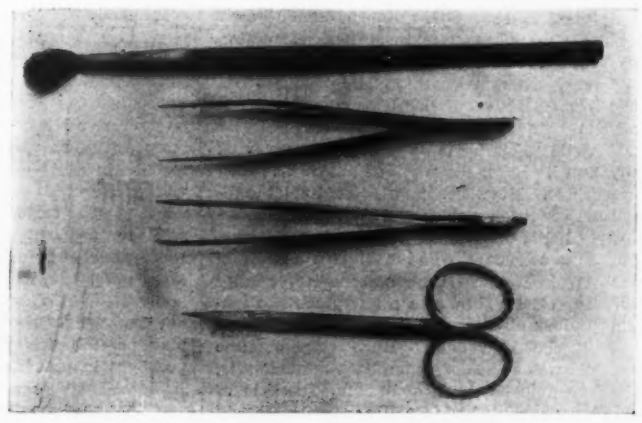
SECURING AZALEA BLOOMS TO THE STEMS BY MEANS OF GUM.

WIRING A ROSE TO PREVENT IT FROM OPENING.

FREEING A CHRYSANTHEMUM FROM INJURED PETALS.



REMOVING IMPERFECT PETALS FROM A CARNATION.



THE FLOWER DOCTOR'S IMPLEMENTS.

THE FLOWER DOCTOR.

To begin with, the flower doctor, no less than his namesake in the medical profession, must have his case of instruments. These are much like a portion of a surgeon's stock in trade; delicate pairs of dissecting scissors, forceps of all shapes and grades, cutting pliers, in addition to a host of brushes in all sizes. There are also a number of accessories the use of which will become apparent when the flower doctor is seen at his work. The whole paraphernalia, which makes quite a formidable array, includes spray producers, and bottles containing gums and scent essences.

The most ordinary duties of the flower doctor consist in simply correcting imperfections in the flowers which are placed in his hands. A great box full of freshly-gathered rose buds is brought in to him. Many of these are not quite as they should be. A withered, or perhaps a badly developed petal spoils what would otherwise be a perfect flower. With a pair of forceps in his deft hand the doctor rapidly goes over each bloom. This petal, which is out of its place, is put into a right position; that ill-shaped one is torn away altogether. In the end the flower is placed aside without the least blemish to detract from its market value.

If the roses are wanted for some purpose where it is important that the buds should not open, such as for use in a bouquet for instance, each bud must be separately treated. As near to the base of the bloom as is possible, thin wires are cunningly inserted right through the center of the bud, so that all the petals are held in such a way that they can never fall apart. All other kinds of flowers are examined in the same manner as has been described above, faulty petals removed and displaced ones put into the correct position. It is not at all an unusual thing in the case of chrysanthemums, to go over the flower with an instrument much resembling a pair of curling tongs, and with delicate twists bring the petals over in an elegant curling fashion.

Some of the most desirable flowers, from the florist's

* From American Homes and Gardens. Published by Munn & Co.

point of view at any rate, have been provided with only very weak stems, and sometimes with scarcely any stem at all. The beautiful Marechal Niel rose can scarcely hold up its head, while the fragrant white tuberose blooms by the time they have been gathered from the central stalk have not more than a fraction of an inch of stem. Such flowers could never take their place in decorative schemes in the condition in which Nature has given them to us. But your flower doctor can easily get over such trifling difficulties as these. With metal thread the weak stems are strengthened, often in such a way that it is impossible to detect the supports, and the blossoms without stems are provided with ones made of stout wire. All this is done so cleverly that by the time the flower takes its place on the dinner table, or in the bridal bouquet, no one can say that the bloom has received any attention from the hands of man at all.

It has been held that to attempt to give scent to the rose is an undertaking which is altogether ridiculous. Nevertheless the flower doctor does not view the matter at all in this light. It is a sad fact that many of our modern strains of one-time fragrant flowers are more and more wofully lacking in sweetness. Some of the most lovely varieties of roses, the finest kinds of violets, are almost scentless. This will never do for the florist; buyers expect their roses and violets to smell pleasantly, and if Nature does not provide the wherewithal, well, the deficiency must be made up somehow. And it is just here where the spray-producer comes in so usefully, hissing out its sweet vapor in response to the ball pressure over the fresh blossoms. It is only fair to say that the doctor is very careful to use only the finest scent, which, of course, has had its origin in flowers, and is a natural product. He is also most particular in selecting the right kind of fragrance for each bloom, so that the fair lady who buries her nose in this bunch of violets has not the least conception that the purple blossoms have been tampered with in any way. Of course good scent is so permanent that its odor will remain quite as long as the flowers last, and often much longer, making folk wonder at the delightful fragrance of the modern blooms even when they are dead.

One phase of the flower doctor's work it is not easy, for a person who loves blossoms as Nature made them, to write of without protest. This will be seen to be nothing less than sheer mutilation, for which there is really little excuse. There are certain purposes for which it is considered very desirable that the flowers used should be entirely white. Popular favor has declared that as a general rule the blossoms used for church decoration, and in the composition of wedding and christening bouquets, wreaths, etc., must be of spotless purity. To this end your flower doctor performs a cruel operation on the lovely white Easter lilies. As is well known, the blooms of these lilies produce anthers to their stamens, which are large and most plentifully supplied with golden pollen. This golden dust as it reaches maturity is apt to fall off and sully the white petals, and in order to prevent this the expert just as each bud opens, carefully removes each anther with his forceps, with the result that the lily is shorn of a good deal of its natural beauty. Perhaps even a worse instance of this mutilation is seen in the case of the poet's daffodil (*N. poeticus*). The charming crimson eye in the center of this flower stands out in fine relief against the snowy ring of petals, but in such a state the florist will have none of the flower, if the purpose demands a white blossom. A dreadful deed again must be accomplished by the doctor. With a delicate pair of scissors the brilliant bordering of scarlet is trimmed away from the cup, and one of the loveliest of the Narcissi is divested of its most attractive feature. This is flower surgery at its very worst, and it is not easy to justify such practices; indeed, it is much to be hoped that ere long these methods will be held to be outside the legitimate work of the specialist. There is all the difference in the world between providing a flower with an artificial stem and cutting away its petals, and by so doing destroying most of its natural beauty.

It seems a strange thing to talk about sticking flowers with gum, and yet this is a very common practice in the florist's workshop. All the lovely azaleas in pots which delight our eyes during the spring months have been doctored with a vengeance. Azalea blooms drop very quickly, some time before the petals of the flower really begin to fade, and were it not possible to fix the blossoms in some style or other the plants could hardly be marketed at all. In order to prevent the flowers from falling too quickly, at the joint of each stalk with the stem, a wee drop of gum is placed by means of a brush, which when dry holds the flower firmly in position. As may be imagined, the sticking on of azalea blooms is a process which is tedious in the extreme. Many fine plants will bear hundreds of flowers, and as each of these will require attention individually, it will be seen that the matter is no small one. In the case of other flowers where it is known the petals are apt to be shed somewhat hastily, a touch of pure gum here and there will often very much lengthen the life of the blossom. If this has been done with proper skill no one need ever detect that the flower has been attended to in any way.

In most big flower stores a person with some knowledge of flower doctoring is usually retained. Those flowers which look so fresh were really not picked today at all, nor is it necessary that they should have been; but they have been stimulated to hold up their heads a while longer by clever treatment. Although methods vary slightly, they mostly consist in placing the stems of the flowers in very hot water for five minutes, and then putting them in a cool, dark cupboard for an hour or so. Just before the blossoms are placed on the display counter it is not an unusual practice to spray them over with clear spring water. This produces a delightful effect of glistening dew drops on petal and leaf, which is bound to make the show pleasant and attractive in the eyes of would-be buyers. After all, it must be admitted that the flower doctor does very much to assist in the meeting of the greater demand for blossoms, which it is safe to say, is one of the best desires which the public has evidenced for a long time.

CIRCUS AND MUSEUM FREAKS.

CURIOSITIES OF PATHOLOGY.

THE announcement from Ansonia, Conn., of the recent death of "the only living skeleton," directs attention to the entire class of freaks, or human prodigies, as they themselves prefer to be called. They have for the medical man a more than ordinary and passing interest. Most of these humble and unfortunate individuals, whose sole means of livelihood is the exhibition of their physical infirmities to a gaping and unsympathetic crowd, are pathological rarities worthy of more serious study than they usually receive. Their mortality rate is high, and many of those recently most famous are already dead or have been retired from public view by chronic invalidism. A few days ago there died in Chicago Maggie Minott, one of the most extraordinary of the nanosomes, or true dwarfs. She was twenty-seven inches high and weighed but twenty-five pounds. Most of these pygmies are types of infantilism. An exception was the comparatively robust and virile "Tom Thumb," who had a vigorous and manly beard. Bass, the "ossified man," also died several years ago. He was a man of unusual intelligence, and his condition was caused by an extreme degree of polyarthritis deformans. He was injured by a careless museum attendant, who let him fall as he was being removed from a carriage, and he never fully recovered. The elastic skin man a few years ago contracted tuberculous disease of the lungs from exposure of his scantily clad body on the drafty stage of dime museums. His was a case of generalized dermatolysis, and he had an amusing trick of drawing the skin of his forehead down over his face like a veil. Closely allied to him was the Russian dog-faced man, with features marvelously resembling those of a Scotch terrier. He and the bearded lady, who was wont to convince the most skeptical by a liberal but chaste display of the matronly charms of her rounded and well-developed figure, were unusual examples of hypertrichosis. The blonde loveliness of the Circassian beauty, who delighted our unsophisticated younger days, was, of course, a case of albinoism, and the "wild men of Borneo" and Barnum's "what is it" we now recognize, in the maturer years of professional experience, as cases of microcephalous idiocy, gathered for the most part from the negro population of our southern plantations.

Most examples of gigantism are cases of acromegaly—as was notably Chang, the Chinese giant, who had the gentle, emotional temperament and, in his last days, the excessive muscular debility so characteristic of this disease. The various "human pin cushions" who have been on exhibition would doubtless present for the neurologist curious areas of anæsthesia and analgesia, which he would properly refer to definite lesions in the spinal cord. Many students of the late Dr. E. C. Seguin's will remember the "blue man" whom he often showed in his clinic at the College of Physicians and Surgeons. He owed his peculiar cerulean gray hue, approaching the color of a maltese cat, to the argyria of his tissues produced by the prolonged administration of silver nitrate—a melancholy victim of credulity as to the efficacy of this drug in locomotor ataxia.

In parts of southern Europe there was formerly plied a nefarious trade in maiming and mutilating young children for the purpose of producing distressing deformities to excite pity and thus induce alms. An instance of such mutilation is made romantic use of by Victor Hugo in his story *L'Homme qui rit*. In most civilized countries there are now enacted laws forbidding the public exhibition of monsters and revolting deformities. A more refined and a more humane popular taste now frowns upon such exhibitions, and they are less profitable to their promoters. The profession of museum freak is passing. The genuine *lusus naturæ* is, however, always a valuable subject of study for the scientific physician, which may add to our knowledge of development of normal types and may possibly illuminate many difficult and obscure problems in pathology.—New York Medical Journal.

WASTE OF MINERAL WATER MANUFACTURE.

SULPHATE of magnesia, the manufacturing residue, consists of water (water of crystallization) 51.2 per cent, sulphuric acid 32.1 per cent, and magnesia 16.7 per cent. The last two are indispensable plant foods. The magnesia especially is present in proportionately large quantities in the seeds of agricultural growth, in the kernels of grain varieties, in leguminous plants, etc. Sulphate of magnesia, in the condition in which it is furnished by the mineral water factories, contains 6 to 7 per cent of by-products, and is therefore, according to Dr. Freiherr v. d. Goltz, almost equal in value to the pure salt, for agricultural purposes.

A special fertilization of plants with magnesia, especially the sulphate, has frequently proved satisfactory.

It is recommended that the epsomite be mixed with an equal quantity of loose earth and then this mixture applied to the young plants or spread over the freshly verdant fields. For leguminous growths we take ½ to ¾ hundredweight of sulphate of magnesia per acre, 1 to 1½ hundredweights for clover and pasture. For spreading over stable manure or manure heaps, epsom, etc., is often recommended.

Luhmann advises the production from this waste of pure epsomite. Inasmuch as the epsomite is not contaminated with other soluble salts, but only mechanically mixed with small quantities of insoluble residues and finely divided sulphate of lime (gypsum), it is possible to obtain, by systematic extraction, a clear, pure, concentrated epsomite solution. The exliviation is effected in a series of tubs of which, at the commencement, the first is filled with a concentrated solution of the magnesite residue in water. After the white gypsum precipitate has settled to the bottom, the supernatant clear lye is drawn off by means of a siphon and run into a large collecting tub. Fresh water is run on to the gypsum slime, it is stirred up, and after the solid matter has settled, the dilute clear lye is drawn off into the second tub, where it is saturated with epsomite by the addition of a fresh quantity of magnesite residue. In order that the tub may be completely filled, a sufficient quantity of water is added upon the solution of the residue in the second tub. To the deposit in tub No. 1 water is again added, and the whole stirred up. After the settlement of the slime, the lye from No. 2 is run into the collecting tub and the now very dilute lye from No. 1 run into No. 2, while in No. 3 tub, with the dilute lye, water and a new supply of residual matter, concentrated epsomite, is produced. The work of extraction is thus continued and new tubs are taken in until the first contains only pure water and the Baumé aerometer sinks to 0. By means of this aerometer the concentration of the lyes is determined. The saturated epsomite solution, at a temperature of 59 deg. F. (15 deg. C.) has a specific gravity of 1.299 = 16.5 B. As soon as the aerometer shows 0 deg. in the first tub after the water has been drawn off, the gypsum slime is removed and it now becomes the last in the series of the extracting vessels and in it, with a fresh supply of residual substance and dilute lye, concentrated epsomite solution is prepared.

The collected concentrated epsomite solution is evaporated in an iron kettle, until, on the surface, a film of salt is formed, or until the aerometer shows a concentration of 37 deg. After the iron in solution has been precipitated by sulphur hepar, the fire under the kettle is drawn, and the lye left to stand for a time

until it has cleared. The clear lye is drawn off by means of a siphon, filtered through conical filter bags and run on to a surface cooler, in which, after cooling, the epsomite separates in small crystals. As soon as the salt has collected on the sides of the cooler to a thickness of about a tenth of an inch, the crystals are stirred up with a spatula, so that the crystals formed later will not be too large and the mass of salt will not settle too firmly on the bottom. After the mother lye has been drawn off through the discharge tap of the cooler and returned to the kettle, the crystalline mass is heaped on to a roomy draining filter and finally dried in a drying room on hurdles. The iron kettle is again replenished with cold saturated epsomite solution from the leaching plant in order to prepare a new complement of crystallized epsomite.—Dr. Theodor Koller in Verwertung von Abfallstoffen jeder Art.

IS MARS HABITABLE?*

DR. WALLACE'S REFUTATION OF LOWELL'S THEORIES.

BY WILLIAM J. S. LOCKYER.

In the year 1903 Dr. Wallace published an interesting and fascinating volume entitled "Man's Place in the Universe," a book which created quite a large perturbation in the thinking world. In it he marshaled together a great number of lines of astronomical research, pointed out the deductions which had generally been made from them, and by weaving them together in a masterly way, drew some very definite conclusions from them.

These conclusions he "claimed to have shown to have enormous probabilities in their favor," and two of them which need only here be mentioned, were as follows:

1. That no other planet in the solar system than our earth is inhabited or habitable.

2. That the probabilities are almost as great against any other sun possessing inhabited planets.

Not only, then, was a wet blanket thrown over many of our favorite dreams relating to the probable doings of living creatures in other worlds, but quite a shock was received when our near neighbor Mars was ruled out of court and declared to be uninhabitable!

We had all become accustomed to regard the changes of hue on the planet's surface as due to the varying tints of waxing and waning vegetable growth. We pictured to ourselves the great ice caps melting away under the heat rays of the approaching summer sun. The gemination of the canals and the later duplication of some of them were the means of making the best use of the water after its release from the poles, and the oases served as distributing centers. These and many other variations of absorbing interest all tended to indicate a world of change, very different from the serenity on, let us say, the moon but more approximating to those of the earth when seen from afar.

If we are to take the view of the writer of this book, such changes must be looked on rather as signs of death than of life, since water, he says, there is none.

During the last decade or more the planet Mars has received a considerable amount of attention. By the energetic, persevering, and painstaking astronomer, Prof. Lowell, every portion of the planet's surface has been under close observation, and the surface features have been chronicled on nearly every occasion when favorable opportunities presented themselves.

It is not too much to say that just as the name of Schiaparelli is now, and always will be, identified with the planet Mars, so will that of Lowell be handed down to posterity for his magnificent consecutive series of observations.

In the year 1905 Prof. Lowell published a very valuable volume describing in great detail, and copiously illustrated with sketches and charts, the observations made by him at the oppositions of 1894, 1896, 1898, 1901, and 1903.

In 1906 he published a volume which was intentionally devoid of technicalities. This was meant to contain a summary of the main results, derived from the discussion of all the data, and his own deductions as to the probable cause or causes of the surface features and their changes. He was led finally to make the following statement with regard to the habitability of Mars: "That Mars is inhabited by beings of some sort or other we may consider as certain as it is uncertain what those beings may be."

This very definite statement, made after the issue of Dr. Wallace's book to which reference above has been made, has called into being the present small volume by the same author. Although, as we read in the preface, it was commenced as a review article on Prof. Lowell's recent book, it became so extended that it was considered expedient to publish a more detailed examination of the various physical problems involved in order to give a complete presentation of the opposite view held by Prof. Lowell.

In directing attention to the contents of this book it is not proposed to enter into each point of the arguments dealt with, but it will be sufficient to refer briefly to some of them.

The first two chapters are devoted to a general survey of the observations of Mars made by early workers, concluding with those made by Prof. Lowell. With regard to the last-mentioned, the author pays a high tribute to the technical skill and persevering labor of Prof. Lowell, and, while accepting all his observations as valid, only parts company with him "as regards the startling theory of artificial production which he thinks alone adequate to explain them."

The two main topics dealt with in Chapter III. are the questions of the elaborate system of the canals and the water supply. The author takes the view that if the surface of the planet is so wonderfully smooth and level as Prof. Lowell states it to be, then the great network of straight canals could possibly have been constructed by intelligent beings for irrigation purposes. But he points out emphatically here that, if it were so smooth, then such a system would be quite unnecessary, as the water would naturally irrigate as much of the surface as it could reach. If it be admitted for a moment that the polar caps are frozen water, he joins with the late Miss Clerke in the view that the excessively scanty supply of water, coupled with the loss through evaporation, could not possibly serve the innumerable canals.

As the habitability of Mars depends on the presence of water, the question of the evidence for the presence or absence of water vapor is dealt with in Chapter IV. Dr. Wallace first directs attention to the observation of the melting polar caps, and the deduction made by Prof. Lowell that this melting and reforming affirm the presence of water vapor in the atmosphere. It will be remembered that Prof. Lowell observed blue borders on the edges of the polar caps as they melted, and he stated that "water alone could do this." The author entirely disagrees with this interpretation, "the only proof," as he says, "he gives that the caps are frozen water." He points out that for water to be blue it must be deep, and this cannot be so on Mars because its surface is so level.

He finally indicates that there are two very important pieces of evidence which point to a lack of water vapor on the Martian planet—the spectroscopic evidence,* which must be taken into account, entirely negatives the view of the presence of water vapor; and Dr. Johnstone Stoney's proof that aqueous vapor cannot exist permanently there, or on any planet, unless its mass is at least a quarter that of the earth. As the mass of Mars is only one-ninth that of our earth, the planet must have parted with its water vapor many, many centuries ago.

In the next chapter the important question of the probable temperature of the planet is taken in hand, and the author shows to his own satisfaction, and probably to that of the majority of his readers, that the temperature must be far too low for the possibility of any formation of a high form of organic life. He introduces also a note stating the view on this point given previously by Prof. J. H. Poynting, who showed that unless an assumption be made that there exists some quality in the atmosphere of Mars entirely different from any found in our own, the temperature of Mars cannot be as high as the value given to it by Prof. Lowell.

The author ingeniously considers the condition of the Martian atmosphere as being intermediate between that of the earth (a dense atmosphere) and that of the moon (practically no atmosphere). He then refers to many researches on lunar radiation as regards measurements made on portions of the surface exposed and unexposed to the sun's rays. He recalls the important function of a planetary atmosphere, like that, for instance, of our own earth, in retaining and cumulating solar heat and reducing radiation into space. He finally deduces that the Martian conditions of temperature must approximate more to those of the moon than to those of the earth. Further, he lays great stress on the impossibility of the seasonal change at the Martian poles being an apparent freezing and thawing of water, and he expresses his view in the following words:

"If the moon, even at its equator, has not its temperature raised above the freezing point of water, how can the more *distant* Mars, with its *oblique* noon-day sun falling upon the snow-caps, receive heat enough, first to raise their temperatures to 32 deg. F., and then to melt with marked rapidity the vast frozen plains of its polar regions?"

In the chapters referred to above the author has presented his views as to the extreme probability of a very low temperature and of the absence of water vapor on Mars, and consequently replies to the question "Is Mars Habitable?" in the negative.

In the remaining portion of the book he makes an alternative suggestion as to the cause or origin of the surface markings and changes recorded on the planet. Just as he stated he had to part company with Prof. Lowell when he considered the latter's deductions drawn from the discussion of his facts, so we must part company with Dr. Wallace, and disagree with his views on the peculiar, and what seems unique, origin of the planet Mars.

It may be recalled that Prof. W. H. Pickering, next to Prof. Lowell, has made the most minute study of the Martian surface details during the last decade or more. Further, he had the advantage of making his observations under practically similar climatic conditions and, in addition, he has also closely studied the lunar features under specially fine instrumental and atmospheric conditions.

Prof. Pickering's suggested origin of the Martian canals is that they, like the rifts and streaks on the moon, are caused by volcanic action due to internal stresses set up by the cooling of the planet's heated interior. Dr. Wallace refers here to Prof. Pickering's work, and, like him, looks upon the canals and oases as the results of cooling.

In order, however, to create conditions on a planet which, when cooling, should be capable of producing an enormous network of fissures of large dimensions, and thus give a representation of the chief surface markings as seen on Mars, he suggests the following very ingenious but very questionable mode of planetary formation, rather straining even the very flexible meteoritic hypothesis.

He supposes that the planet began to be formed on the principle of the meteoritic hypothesis, but that the aggregation of the meteorites involved in the process took place so slowly that the heat generated by the bombardments was lost equally quickly by radiation. So gradual, he suggests, did this state of things occur that the planet attained its present size, minus about 50 to 100 miles of the radius, having grown to this dimension "as a solid and cold mass."

He then tells us that this cold mass, in its revolution round the sun, at a later stage of its life, passed through at each revolution a large and dense mass of meteorites. So violent were the impacts that the "inpour of the fresh matter first heated and later on liquefied the greater part of it, as well perhaps as a thin layer of the planet's original surface."

In this way the author produces a thin shell of liquid or plastic material covering a solid and cold interior, which he requires for the explanation of the surface features of Mars. At the termination of this series of annual bombardments this thin shell of heated material would rapidly cool, and, as it is superimposed on a globe of cool matter, craterlets would first be formed, and subsequently large fissures due to contraction. The fissures would have no regard for the equator, but would cross from one hemisphere to the other, as the canals are recorded to do.

The superficial tensions would render the cracks eventually very broad and deep, and where they crossed each other, holes, giving the appearance of oases, would be formed. In time, both fissures and oases would gradually crumble away at their sides, in consequence of the alternate expansion and contraction of the material, due to the presence or absence respectively of the sun's heat.

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* Nature.

"Is Mars Habitable?" A critical examination of Prof. Lowell's book, "Mars and Its Canals," with an alternative explanation. By Dr. Alfred Russel Wallace, F.R.S. Pp. xii + 110. London: Macmillan & Co., Ltd., 1907.

* Since Dr. Wallace's book appeared definite spectroscopic proof of water has been obtained.

Although the author accounts for many of the other surface features and changes as recorded on the Martian disk, he is unable to suggest any satisfactory explanation of the doubling of the canals.

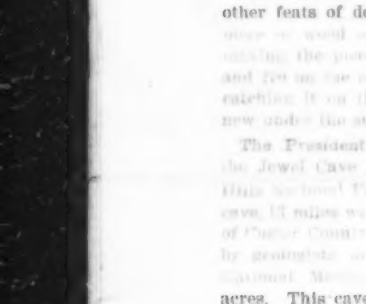
Enough, perhaps, has been said to indicate that in these pages we have some very original ideas on a subject of all-absorbing interest. It must nevertheless be left to the reader to form his own judgment as to the probability of the views put forward when he has carefully read the book.

We can unhesitatingly recommend this book to a very large circle of our readers, and more especially to those who have followed the previous publications relating to this subject. The last word on this difficult question has not been said yet, and the present issue will very likely rekindle the flame.

SCIENCE NOTES.

The growth of ballooning, says a contemporary, has led to many curious investigations touching the atmosphere and its inhabitants. By the use of anchored balloons with self-registering instruments some of the experiments of deep sea sounding have been repeated aloft. At Strasburg sounding balloons have been sent to a height of nearly 26,000 yards, and 19,000 yards to 20,000 yards is not an uncommon height. One of the astonishing things said to have resulted is the discovery at a height of 14,000 yards of an isothermal zone in which, contrary to experience up to that height, temperature does not diminish with recession from the earth.

Much has been written about the game of diabolo. We are told that it flourished in China some centuries ago, and the French courts have been asked to decide the delicate question whether the toy now in vogue is or is not identical with the "diable" that amused the Parisians of the Directory. However this may be, Count Cameron, in his book entitled "Across Africa," says that in 1874, in the heart of Africa, near Lake Kassali, he saw a slave who had diverted him with other feats of dexterity, balance an hour-glass shaped



acres. This cave, which was explored as late as 1906, has been found to consist of a series of chambers connected by narrow passages with numerous galleries, the walls of which are encrusted with a magnificent layer of calcite crystal. The opening of the cave is situated in Hell Canyon, the walls of which are high and precipitous. The surface of the country in which the cave is located consists of a high rolling limestone plateau about 6,000 feet above sea level. The area is almost entirely covered by a forest of bull pine, a considerable portion of which is merchantable, while the remainder consists of a vigorous young growth. The Jewel Cave National Monument will now be given permanent protection by virtue of the Act of June 8, 1906, which provides that objects of scientific interest may be declared National Monuments if such action is deemed necessary for their preservation and protection.—Science.

It is now definitely proven that the best way to exterminate the white grub, the larva of the cockchafer, May beetle, or "June bug," is to destroy the beetles as soon as they appear. The life cycle of this insect comprises three years and it is only in every third year that the beetles appear in very great numbers, at least in the district here considered. Hence the war should be waged with especial vigor in the years when the enemy appears in force, though the stragglers that come in other years should not be spared. The agricultural society of Meaux, which has waged unrelenting war on the cockchafer for the past eighteen years, has published statistics which give reason to hope that if the fight is persistently kept up this pest of agriculture will soon be completely exterminated. The society has offered bounties for the collection of cockchafers, amounting sometimes to 60 centimes or 12 cents for a kilogramme, or about 1,000 beetles. Following are the quantities collected, in tonnes or thousands of kilogrammes, in each of the years of abundance: 1889, 143; 1892, 122; 1895, 35; 1398, 104½; 1901, 33½; 1904, 24½; 1907, 8. Except for 1898, when there was a large temporary increase due to some unknown cause, the figures show a regular decrease and those of the last years indicate that the species is rapidly approaching extinction in this district. The collections of the seven years of abundance aggregate 470 tonnes, or 470 million beetles. Supposing that half of these were females and that each female would have produced 40 larvæ—and these are low estimates—the number of white grubs thus eliminated was 9,400 millions. As each grub causes damage to the extent of at least one centime or 1/5 cent, the saving effected in eighteen years in one small district by this vigorous war on the cockchafer amounts to 94 million francs or about $19,000,000. The example of Meaux should be followed wherever the white grub abounds.

ENGINEERING NOTES.

A notable rolling mill engine has recently been built for the Carnegie works of the United States Steel Corporation that ranks among the largest reciprocating engines ever built. It is a horizontal twin tandem engine, with 42-inch and 70-inch by 54-inch cylinders, designed for operating condensing with steam at 175 pounds, and for a maximum speed of 200 revolutions per minute, at which speed it has a maximum capacity of 25,000 horse-power. The engine erected has a total weight of 550 tons, and some of the individual parts are very large, two of the frame castings weighing after machining 118 tons each and requiring special reinforced cars for their transportation.

Consul-General John P. Bray reports that a trial was recently held at Melbourne in the presence of representative Australian mining men of a new diamond drill, the invention of the officers of the department of mines of Victoria. Mr. Bray describes it thus: The leading feature of the new drill is its portability, the total weight of the machine being only 400 pounds, as compared with 3 or 4 tons—the weight of the machines now in use. The diamond drill can be worked either by hand or motive power, being capable of boring 300 feet by the former and 500 feet by the latter process. It bores a 2-inch hole, producing a core 1¼ inches in diameter. It is considered that the drill will prove a valuable adjunct in developing the mining industry in this country, as it will be the means of opening up districts hitherto regarded as inaccessible, owing to the difficulties of transporting the heavy drills now in use.

A special exposition devoted to industrial alcohol

signed for the transport of farm laborers or products. There will also be a concourse for automobile fire apparatus. The exposition will be international in character, and persons who may intend to exhibit are requested to apply for the regulations to the Secretary of the Exposition, 24 rue Notre Dame, Bourges. The Minister of Agriculture is to give his patronage to the exposition, and it promises to bring out some interesting apparatus and products.

The results obtained from some interesting experiments undertaken to ascertain the bursting strength of malleable iron pipe fittings, were published in Power some time ago. These experiments were undertaken by the Pittsburg Valve and Fittings Company, and the tests were made on 4-inch standard threaded malleable iron tees, both black and galvanized. The metal of all the fittings was ¼ inch thick on the body portion. It was found that the average bursting pressure for the black fittings was 2,900 pounds per square inch, and for the galvanized fittings 2,833 pounds per square inch. The working pressure recommended by the manufacturers for these fittings is 150 pounds, giving thus a factor of safety of about 19. One of the interesting facts proved by these experiments is that the galvanized fittings can stand practically the same pressures as the black, which is contrary to the expressed belief of many users of malleable fittings, who have been very positive in their statements that galvanizing greatly weakened the strength of the pipe, because the dipping of the fitting in a bath of molten zinc, and then suddenly cooling it by immersing in cold water, would have a tendency to bring the castings back to the unannealed state, making them hard and brittle. That this theory is not correct is conclusively shown by these tests. As compared with experiments undertaken with cast iron tees, the strength of the malleable fittings is more than 50 per cent greater than that of cast iron fittings. In most cases the malleable fittings developed leakage through minute "pin holes" at pressures ranging from 1,000 to 2,500 pounds. In no instance were these pin holes visible below a pressure of 1,000 pounds with the black fittings, or below 2,000 pounds with the galvanized fittings, while two of the galvanized fittings sustained a pressure of 2,500 pounds before pin holes developed. It is therefore evident that galvanizing is very effective in closing small imperfections or pin holes in the malleable iron.

TRADE NOTES AND FORMULÆ.

Whalebone Substitute.—Cane strips, saturated with a solution of nitrate of iron, Campeachy wood and vitriol, treated with linseed oil varnish and finally polished.

Preservation of Bottle Labels.—To the water to be used in making the paste, add as much borax as it will dissolve, cold. The borax entirely prevents the formation of mold. If the decks of corked bottles, before the capsule is put on, are dipped in borax solution, mold will never grow between capsule and cork. A paste prepared with borax solution, even if kept for a long time, will neither mould nor sour. Gum solution cannot be prepared with borax water because the two substances together form an insoluble combination.

Substitute for Whalebone and Bristles.—Suitable fibers, such as piassara, alfa, Mexican fiber, etc., are saturated with a solution of silicate of soda, either alone or mixed with baryta, felspar or chalk or with any glue, cement, gum, etc. The mass is cut into strips and dried. Hereupon it is covered with a coating that dries in the air, such as glue, shellac, celloid, etc., also with caoutchouc solution, copal, etc., finally it is wound spirally with a covering of silk, cotton, flax, etc. For brushes or brooms, the thin, short fibers are used which are saturated with a resin solution.

Artificial Whalebone.—1. Ordinary rattan is freed from its smooth-glazed exterior covering in a special machine and by means of a decoction of Campeachy wood and an iron stain, dyed black. When dry, it is saturated with a solution of caoutchouc, guttapercha, and sulphur in coal tar oil. After this the rods are steamed in a steaming apparatus under a pressure of 2 atmospheres, whereby the mixture with which the cane is impregnated, is thoroughly hardened (vulcanized), and finally they are passed between rollers whereby they are made absolutely dense and highly elastic. 2. One part caoutchouc, 0.2 part shellac, 0.1 part magnesia, 0.25 part sulphur, 1.25 part golden sulphuret. The caoutchouc (India rubber) must be cut up very fine and then kneaded in with the other ingredients at a gradually rising temperature, which, however, must not be allowed to rise above 284 deg. F. Flattan, split into strips, is treated in the hot mixture for several hours.

Flame Protection for Fabrics (according to Elsner).—Dissolve sulphate of alumina in cold water and add a solution of phosphate of ammonia as long as a precipitate is produced, and finally mix in sufficient salammoniac solution until the precipitate is dissolved again. The fabric is impregnated with this fluid. 2. Bone ashes 10 parts, water 50 parts, sulphuric acid 6 parts; allow to stand for two days at moderate heat, then add 100 parts of water and filter. The fluid is first mixed with a solution of 5 parts of sulphate of magnesia (Epsom salts) in 15 parts of water, and then with so much ammonia that its excess may be detected by the odor. The resulting precipitate is pressed and dried. Two parts of this precipitate should be mixed with 1 part of tungstate of soda and 6 parts of wheat starch, blued with a little indigo-carmine and then boiled with enough water to produce a slimy fluid, with which the fabric must be saturated. 3. a. Priming coat for large wood surfaces, for instance, roof timbers, 100 parts of alum dissolved in 80 parts of boiling water, and, to the cooled solution, constantly stirring, add 25 parts of English sulphuric acid; with this the woodwork must be twice painted. Covering preparation: 10 parts of fresh, skim (lean) cheese and 10 parts of fresh powdered lime, with about 3 parts of water thoroughly worked together; then, constantly stirring, add 10 parts of sand and the necessary quantity of water. *b.* Soluble glass solution, hot. For roofing paper, mixture of soluble glass and chalk. *c.* Blue vitriol, chloride of zinc, and salt brine. *d.* Sulphate of ammonia and gypsum: 100 parts of water, 33.3 parts of sulphate of ammonia, 66.6 parts of gypsum. *e.* 100 parts of water, 25 parts of borax, and 25 parts of sulphate of magnesia.

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